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STATE GEOLOGICAL SURVEY
FRANK W. DeWOLF, Chief

BULLETIN No. 43

ECONOMIC AND GEOLOGIC PAPERS

Geology and mineral resources of the La Harpe and Good Hope Quadrangles
By T. E. Savage and M. L. Nebel

Geology and mineral resources of the Morris Quadrangle
By Harold E. Culver

Geology and mineral resources of the Kings Quadrangle
By J Harlen Bretz

Geology of northeastern Adams County
By Louis W. Currier

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STATE OF ILLINOIS
DEPARTMENT OF REGISTRATION AND EDUCATION

DIVISION OF THE
STATE GEOLOGICAL SURVEY
FRANK W. DeWOLF, *Chief*

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Geologist

LETTER OF TRANSMITTAL

State Geological Survey Division, July 12, 1923

A. M. Shelton, Director, and Members of the Board of Natural Resources and Conservation,

Gentlemen: I transmit herewith four reports with my recommendation that they be published together as Bulletin No. 43 of our geological series. These reports are: (1) Geology and mineral resources of the La Harpe and Good Hope quadrangles, by T. E. Savage and M. L. Nebel; (2) Geology and mineral resources of the Morris quadrangle, by Harold E. Culver; (3) Geology and mineral resources of the Kings quadrangle, by J Harlen Bretz; and (4) Geology of northeastern Adams County, by Louis W. Currier.

The first three reports give not only an account of the rock formations and mineral resources of the various areas involved, but the facts and interpretations are presented in a way that is designed to contribute to the educational status of our citizens with respect to the natural history of our environment. The report on northeastern Adams County is intended primarily to embody our present knowledge of the possibilities of oil occurrence in that area.

The first, second and fourth reports have been published as extracts under the direction of my predecessor, Mr. F. W. DeWolf; hence the retention of his name on the cover and title page is entirely proper. The third report is here published for the first time.

Very respectfully,

Morris M. Leighton, *Chief.*

CONTENTS

Page

1. GEOLOGY AND MINERAL RESOURCES OF THE LA HARPE AND GOOD HOPE QUADRANGLES, BY T. E. SAVAGE and M. L. NEBEL.............................. 9

2. GEOLOGY AND MINERAL RESOURCES OF THE MORRIS QUADRANGLE, BY HAROLD E. CULVER.......... 95

3. GEOLOGY AND MINERAL RESOURCES OF THE KINGS QUADRANGLE, BY J HARLEN BRETZ................. 205

4. GEOLOGY OF NORTHEASTERN ADAMS COUNTY, BY LOUIS W. CURRIER.................................... 305

GEOLOGY AND MINERAL RESOURCES OF THE LA HARPE AND GOOD HOPE QUADRANGLES

By T. E. Savage and M. L. Nebel

OUTLINE

PAGE
Introduction 13
  Location and area 13
  Topography of the La Harpe and Good Hope quadrangles 13
    Relief 13
      General features 13
      Upland prairies 14
      Erosion slopes 15
      Alluvial plains 16
    Drainage 16
      Streams 16
  Culture 17

Stratigraphy 18
  General character of the rocks 18
  Detailed well sections 18
  Rocks not exposed 22
    Cambrian system 22
      Upper Cambrian ("Potsdam") sandstone 22
    Ordovician system 23
      "Lower Magnesian" limestone 23
      St. Peter sandstone 23
      Galena-Platteville limestone 24
      Maquoketa shale 25
    Silurian system 26
    Devonian system 28
    Mississippian system 28
      Kinderhook shale 28
  Rocks exposed 29
    Mississippian system 29
      Burlington limestone 29
      Keokuk limestone 31
      Warsaw formation 33
      Salem formation 34
      St. Louis limestone 35
    Pennsylvanian system 38
      Pottsville formation 39
        Distribution and thickness 39
        Character of the Pottsville rocks 40
      Carbondale formation 48
        Murphysboro (No. 2) coal and associated strata 49

Stratigraphy: Rocks exposed (Continued)

PAGE
- Quaternary system 51
  - Pleistocene series 52
    - Differentiation of the deposits 52
    - Kansan (?) drift 52
    - Yarmouth (?) soil 55
    - Illinoian drift 56
    - Sangamon soil 58
    - Loess 60
  - Recent series 61
    - Alluvium 61

Structure 61
- General statement 61
  - Use of structure-contour map 62
  - Accuracy of contours 62
- Structure of La Harpe and Good Hope quadrangles 63

Geologic history 64
- Paleozoic era 64
  - Cambrian period 65
  - Ordovician period 65
  - Silurian period 66
  - Devonian period 66
  - Mississippian period 66
  - Pennsylvanian period 67
  - Post-Pennsylvanian deformation 69
- Mesozoic era 69
- Cenozoic era 69
  - Tertiary period 70
    - Pre-glacial topography 70
  - Quaternary period 71
    - Pleistocene epoch 71
    - Recent epoch 72

Mineral resources 72
- Clay and shale 72
- Coal 75
  - Pottsville coals 75
    - Rock Island (No. 1) coal 75
  - Carbondale coals 76
    - Murphysboro (No. 2) coal 76
    - Springfield (No. 5) coal 77
- Sandstone 77
- Limestone 78
- Lime 78
- Sand and gravel 78
- Cement rock 80
- Metallic ores 80
  - Iron, zinc, and other metals 80
- Oil and gas 81
  - Possible oil-bearing horizons 82
    - Pottsville sandstone 82
    - Silurian dolomite 82

Mineral resources: Oil and gas (Continued)

PAGE

The Hoing sand 82

Horizons below the Hoing sand.................................. 83

Relation of accumulation to folds in the oil-bearing bed............... 84

Localities already tested 86

Recommendations 87

Gas in glacial drift 87

Water resources 87

Rural supplies 87

Urban supplies 89

Soils 92

Summary of mineral resources...................................... 93

ILLUSTRATIONS

PLATE

I. Geologic map of the La Harpe and Good Hope quadrangles, including a columnar section..In pocket

FIGURE

1. Index map of central Illinois, showing the location of the La Harpe and Good Hope quadrangles.. 12
2. Contact of the Kinderhook shale and Burlington limestone in NE. ¼ sec. 24, T. 9 N., R. 4 W. (Media), in the bank of Ellison Creek, La Harpe quadrangle 29
3. Salem limestone and shale on La Harpe Creek in the NW. ¼ sec. 9, T. 6 N., R. 5 W. (Fountain Green) 35
4. Undulating and brecciated St. Louis limestone exposed in La Harpe Creek in the NW. ¼ sec. 9, T. 6 N., R. 5 W. (Fountain Green)............. 37
5. Pottsville strata exposed on Baptist Creek in SW. ¼ sec. 6, T. 6 N., R. 4 W. (Hire) 39
6. Strongly ripple-marked Pottsville sandstone along La Harpe Creek, NW. ¼ sec. 35, T. 7 N., R. 5 W. (La Harpe)............................. 42
7. Exposure of Pottsville sandstone along Cedar Creek in NW. ¼ sec. 21, T. 9 N., R. 1 W. (Berwick).. 45
8. Gently inclined Pottsville strata, on Swan Creek, NE. ¼ sec. 16, T. 8 N., R. 1 W. (Greenbush) 47
9. Sketch map of Good Hope and La Harpe quadrangles showing generalized pre-glacial topography 53
10. Yarmouth (?) soil and peat exposed in NW. ¼ sec. 17, T. 8 N., R. 1 W. (Greenbush) 56
11. Diagrams showing conditions governing oil accumulation................ 85
    - A. In oil sands saturated with water.
    - B. In oil sands partly saturated.
    - C. In sands containing no water and only partly filled with oil.

TABLES

1. Relative number of different kinds of pebbles in gravel associated with Illinoian drift 57
2. Analyses of well waters from the La Harpe and Good Hope quadrangles 90

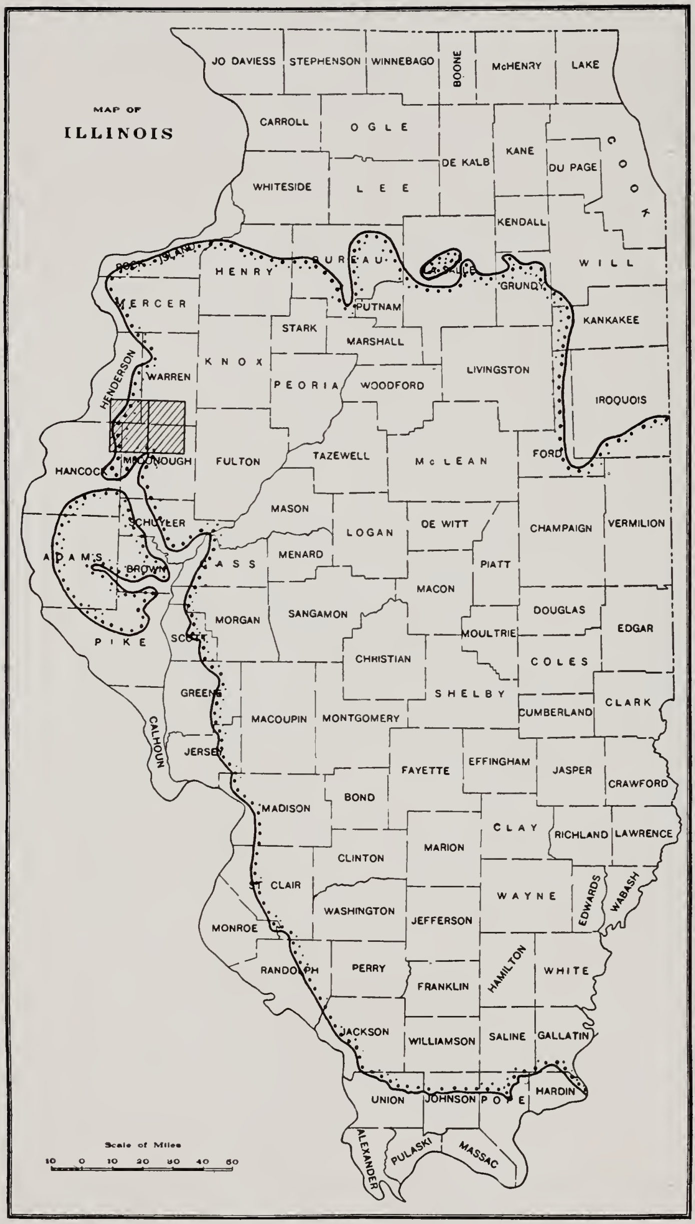

FIG. 1. Index map of central Illinois, showing the location of the La Harpe and Good Hope quadrangles. The stippled boundary outlines the Illinois coal field.

INTRODUCTION

Location and Area

The area covered by this report includes that of the Good Hope and La Harpe quadrangles,[1] topographic maps of which have been made by the State Geological Survey in co-operation with the United States Geological Survey. These quadrangles are located near the west-central border of Illinois, the northwest corner being less than one mile from the floodplain of Mississippi River. Each quadrangle has a length of 15 minutes of latitude, and a width of 15 minutes of longitude which at this latitude gives to each an approximate length of 17½ miles north and south, and a width of about 13 miles east and west. The total area is embraced between 40° 30′ and 40° 45′ latitude, and 90° 30′ and 91° 00′ longitude, and includes about 455 square miles. This area comprises about 194 square miles in the north part of McDonough county; 128 square miles in the south part of Warren; 88 square miles in the southeast part of Henderson; and 45 square miles in the northeast part of Hancock.

Figure 1 shows the position of the quadrangle in the State, and in the coal field.

Topography of the La Harpe and Good Hope Quadrangles

RELIEF

GENERAL FEATURES

The La Harpe and Good Hope quadrangles are a part of the Glaciated Plains province over which the surface of hard rock has been covered more or less deeply with a mantle of glacial till. The ice sheets that moved over the region smoothed down the sharper elevations and filled the depressions, such as the valleys of preglacial streams, with a deposit of unsorted clay, sand, pebbles, and bowlders, known as drift or till. Hence the surface of the Glaciated Plains province is relatively level, except over the areas of the older drift sheets where stream erosion has been continuously active on the drift surface for a long time. Over such areas, especially in the vicinity of the larger streams, the topography is rather rough, and considerable relief has been developed.

The La Harpe and Good Hope quadrangles are situated near the west border of one of the older drift sheets, not far from Mississippi River, and the larger part of the surface has been rather strongly dissected by streams. The slopes of most of the elevations and depressions are commonly gentle. The range of relief in the area is about 245 feet. The lowest place is near the southwest corner of the La Harpe quadrangle in the valley of La Harpe Creek in sec. 17, in Fountain Green Township (T. 6 N., R. 5 W.), where the altitude is about 565 feet above mean sea level. The highest places are on the upland near the middle of the west side of the Good Hope quadrangle, in secs. 33 and 34, Point Pleasant Township (T. 8 N., R. 3 W.), where the maximum altitude of the surface is about 810 feet. With the exception of some of the hills in the central part of the area, the features of relief in this region are due almost entirely to erosion by streams.

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[1] The quadrangle is the unit area selected by the United States Geological Survey to be represented on the topographic and geologic maps. It is rectangular in form, and is bounded by parallels and meridians.

Lying within the great Glaciated Plains province the surface of this area, like that of adjacent regions is that of a drift formed plain which lies at a general altitude of 660 to 780 feet above sea level. Into this originally nearly level surface the larger streams have eroded valleys one-fourth to one-half mile wide to a depth in places of 100 or more feet.

The area presents three distinct varieties of topographic forms—upland prairies, erosion slopes, and alluvial plains.

UPLAND PRAIRIES

The main body of upland prairie in the La Harpe and Good Hope quadrangles extends in an irregular belt in a general north and south direction. On the west this upland area is roughly bounded by a line passing through Stronghurst and Blandinsville, and on the east by a line through Roseville and Good Hope. The area comprises the larger part of the east half of the La Harpe quadrangle, and about the west third of the Good Hope. The surface of the greater part of this upland plain is nearly level, the altitude ranging from about 740 to 800 feet. From the borders of this area irregular lobes of upland extend in finger-like projections as divides between the streams, which usually flow in a general east-west or northeast-southwest direction. The elevation of the surface of these lobes of upland declines as the stream valleys are approached. The highest places are in the west central part of the Good Hope quadrangle and adjacent portions of the La Harpe, in Point Pleasant Township (T. 8 N., R. 3 W.), where the altitude of the surface in several places exceeds 800 feet. In a few places near the north side of Sciota Township (T. 7 N., R. 3 W.) the elevation of the surface also reaches 800 feet. From this main area the upland surface slopes away towards the east and west, the decline being more rapid towards the east, except in the extreme northwest and southwest corners of the La Harpe quadrangle, in proximity to streams of rather large size. The continuity of this upland area is broken at the south by the branches of Spring Creek which extend north nearly as far as Sciota, a distance in the quadrangles of three or four miles. At the north end the area is also invaded for a distance of two or three miles by the headwaters of Ellison Creek. The interstream lobes of level upland usually do not exceed one or two miles in width. North of Bushnell, however, are a few square miles of fairly level upland that extends east of the Good Hope quadrangle beyond Avon and Prairie City. Another considerable area of upland prairie lies south of Honey Creek, on each side of Dugout Creek, in Raritan (T. 8 N., R. 4 W.) and Terre Haute (T. 8 N., R. 5 W.) townships.

The lengths of most of the streams in the quadrangles do not exceed fifteen miles, but their valleys are slowly lengthening and deepening, so that the area of level upland is gradually being diminished.

EROSION SLOPES

The larger creeks in the area are bordered by slopes that in many places rise 75 to 100 feet above the valleys. These slopes are usually less than one-fourth mile wide, and were originally covered with forests. Where the meanders of a stream have recently deflected the current against one or the other of its banks undercutting has in many places progressed so far as to expose nearly vertical cliffs of hard rock several feet high. Such rock cliffs are somewhat more numerous on the south side of the streams than on the north. In the Good Hope quadrangle they are conspicuous in places along Swan Creek in secs. 10, 16, 17, and 20, T. 8 N., R. 2 W. (Swan), along Cedar Creek in secs. 20 and 21, T. 9 N., R. 1 W. (Berwick), and along Big Nigger Creek in secs. 7, 8, and 9, T. 8 N., R. 2 W. (Swan). In the La Harpe quadrangle exposures of hard rock are most prominent along Honey Creek and its branches in Terre Haute Township (T. 8 N., R. 5 W.), and in the banks of La Harpe and Baptist creeks in Fountain Green Township (T. 6 N., R. 5 W.).

In other places where side cutting of the streams has not occurred so recently, the hard rocks are concealed by a mantle of unconsolidated material, but their presence near the surface is indicated by the steep lower slope of the valley sides. On the banks where side cutting of the streams has not been active for a long time, gentle slopes have been developed, largely through the action of landslides or slumping, creep, and sheet wash. Some distance back from the escarpments or cliffs made by lateral cutting, the upper slopes are always gentle. Throughout long distances the streams in the quadrangles have eroded their valleys in the surficial materials, loess and till, and have not yet reached bed rock.

The valleys along the lower courses of the creeks are 75 to 100 feet deep, and their bordering banks are rather steep. Towards their heads the valleys become shallower, and their slopes are usually more gentle until they merge gradually into the upland plain. The valleys are in most places relatively narrow but in a few places where some of the streams follow pre-glacial channels, they have broadened their valleys much beyond their normal width in the unconsolidated material that forms their banks. Places of unusual valley widening in surficial materials occur along Kepple Creek in secs. 13 and 14, Macomb Township (T. 6 N., R. 2 W.); along Honey Creek in secs. 10 and 11, Fountain Green Township (T. 6 N., R. 5 W.); and along Crooked Creek in secs. 17 and 18, in La Harpe Township (T. 7 N., R. 5 W.). In places where streams have been cutting in unusually hard rocks, their valleys are much narrower than they are elsewhere. Examples of such constrictions in the width of the valleys are found along Honey Creek in secs. 2, 3, and 8, Terre Haute Township (T. 8 N., R. 5 W.), where the stream is cutting across a ledge of Burlington limestone; and farther north on Ellison Creek in sec. 13, Media Township (T. 9. N., R. 4 W.).

ALLUVIAL PLAINS

All of the larger creeks in the quadrangles have floodplains that extend well up to their heads. Throughout the larger part of their courses in the area the width does not exceed one-fourth mile, but in a few places it reaches one-half mile. The surface of these floodplains is usually higher adjacent to the bordering banks as a result of the deposit of sediment by tributary streams, aided by slumping and sheet wash from the bordering slopes. The streams in the area are all too small to have developed conspicuous cut-offs or abandoned channels in the form of ox-bow lakes.

DRAINAGE

All of the run-off from the surface of the Good Hope and La Harpe quadrangles eventually reaches Mississippi River, but somewhat the larger part of it first drains eastward into Illinois River by which it reaches Mississippi.

STREAMS

The larger streams in the Good Hope quadrangle are Swan Creek and the branches of its tributary Nigger Creek in the north part; and Crooked Creek, and its branches North, Short, Town, Farmers, and Browning forks and Kepple Creek in the south. The more important creeks in the La Harpe quadrangle are Honey Creek, North and South branches of Crooked Creek, La Harpe Creek, and its tributaries Baptist and Little creeks. A few square miles in the south part of the quadrangles, south of Sciota, are drained by Spring Creek, and about an equal area in the north part of each quadrangle is drained by the headwaters of Ellison Creek.

With the exception of the two streams last mentioned, all of the creeks in the Good Hope quadrangle follow easterly or southeasterly courses, while all of those in the La Harpe quadrangle flow towards the west or southwest. Of the streams in the quadrangles Honey Creek, Ellison Creek, and a smaller stream, Dugout Creek, flow directly to the Mississippi, but all of the others belong to the Illinois River system.

All of these creeks flow in narrow, well defined flood plains, and have an average gradient of 10 to 12 feet to the mile.

The watershed between Mississippi and Illinois rivers enters La Harpe quadrangle on the west side about one-half mile north of the Henderson-Hancock county line, and continues nearly due east to the northeast corner of sec. 36, in Terre Haute Township (T. 8 N., R. 5 W.), where it swings about a mile farther north and east as far as the west line of Warren County whence it trends northeast to near the southeast corner of sec. 2, in Point Pleasant Township (T. 8 N., R. 3 W.) and then passes north about two miles west of Roseville. It is noteworthy that notwithstanding the larger size of Mississippi River, the watershed between that and Illinois River lies much nearer the Mississippi than the Illinois, being only 15 miles from the former at the north end of the quadrangles and only 6 miles distant at the south end of the area, while its average distance from Illinois River in this area is about 50 miles. Illinois River has been eroding in softer rocks, yet the position of this divide relative to the Mississippi and Illinois rivers was in large part determined by the deposition of glacial till by the ice sheets, and not by such an unequal rate of erosion of the two streams.

In conformity with the slope of the surface in the quadrangles the tributaries to the creeks north of the Mississippi-Illinois watershed are longer, more numerous, and more dendritic on the south side than on the north, while south of this divide, where the surface slopes towards the south in the La Harpe quadrangle, the tributaries of the larger creeks are usually longer and more numerous on the north side than on the south.

Culture

The larger towns in the Good Hope quadrangle are Bushnell, in the southeast part, with a population of 2,716;[1] Roseville in the northwest quarter, with 952 inhabitants; and Good Hope in the southwest quarter with 353. Smaller villages are Swan Creek in the west central part, and Youngstown and Greenbush in the northeast quarter. In the La Harpe quadrangle are La Harpe in the southwest quarter with a population of 1,323; Blandinsville in the south central part with 1,002; and Stronghurst near the middle of the north end with 836 inhabitants. Raritan in the northeast quarter and Sciota in the southeast are villages with a few score of people.

The area is fairly well provided with transportation facilities. The Toledo, Peoria and Western railroad crosses the south part of the quadrangles, connecting at La Harpe with Burlington and Keokuk. A branch of the Chicago, Burlington, and Quincy railroad passes across the Good Hope quadrangle through Bushnell and Roseville. The main line of the Atchison, Topeka, and Santa Fe railroad crosses the northwest corner of the La Harpe quadrangle, through the town of Stronghurst.

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[1] The population of the towns in the quadrangles is that given in the census report for 1920.

Hard roads have been built in only a few places in the quadrangles, as in and adjacent to Bushnell. Except in the more hilly portions the roads usually follow the land surveys, or section lines, and there are no places in the quadrangles that are more than a mile distant from a public road.

Outside of the towns the area is fairly closely settled. The greater part of the surface is under cultivation, agriculture being the most important industry. A few small factories are located at Bushnell, including one for the manufacture of galvanized iron water tanks, and another for making overalls.

STRATIGRAPHY

General Character of the Rocks

The hard rocks exposed in the La Harpe and Good Hope quadrangles consist mostly of shales, sandstones, and limestones belonging to the Mississippian and Pennsylvanian systems. These are almost everywhere overlain by unconsolidated deposits known collectively as surficial materials, and consisting of loess, glacial drift or till, alluvium, and sand of Quaternary age. Besides the rocks that outcrop at the surface at different places in the quadrangles, older strata representing Mississippian, Devonian, Silurian, Ordovician, and Cambrian systems have been penetrated in deep water wells, or in drillings that have been made in search of oil.

Between the time of deposition of the rocks of these different systems, and also within the systems themselves, there were long breaks in the continuity of deposition, recorded in unconformities of the strata. Hence the rocks that are found in this region do not furnish anything like a complete record of deposition since the time the oldest rocks present were deposited.

A generalized columnar section of the rocks exposed at the surface and explored by deep borings in the quadrangles is shown with the geologic map, Plate I, in the pocket.

Detailed Well Sections

The deepest boring in the quadrangles was put down in 1898 by the Stronghurst and Media Company in the town of Stronghurst for Dr. Harter. This well was drilled in the SE. ¼ N.W. ¼ NE. ¼ sec. 25, Stronghurst Township (T. 9 N., R. 5 W.), to a depth of 1,601 feet and penetrated the upper Cambrian or so-called "Potsdam" sandstone. A record of the well, furnished by Dr. I. F. Harter of Stronghurst and interpreted by T. E. Savage, follows:

Log of well in the town of Stronghurst
Altitude of the surface about 665 feet

	Thickness	Total depth
Quaternary system	*Feet*	*Feet*
Soil and drift	150	150
Mississippian and Devonian systems		
Kinderhook and Upper Devonian		
Shale, gray	165	315
Devonian and Silurian systems		
Limestone	105	420
Ordovician system		
Maquoketa		
Shale	165	585
Galena-Platteville		
Limestone, gray	200	785
Limestone, brown	15	800
Limestone, gray	60	860
St. Peter		
Sandstone	171	1031
Shale, white	25	1056
"Lower Magnesian" limestone		
Limestone, white	10	1066
Shale, white	5	1071
Limestone, white	24	1095
Sandstone, white	20	1115
Limestone	50	1165
Shale	5	1170
Limestone	105	1275
Sandstone	5	1280
Limestone	25	1305
Cambrian system		
St. Croix or "Potsdam"		
Sandstone	296	1601

The city of Bushnell recently drilled a well to the St. Peter sandstone for a municipal water supply and samples of rock drillings below the Quaternary were saved as this well was put down, for the State Geological Survey. From the study of these rock samples compared with the driller's log of the boring, the following record of the well has been compiled:

Log of deep well at Bushnell
Altitude of the surface 651 feet

	Thickness	Total depth
Quaternary system	*Feet*	*Feet*
Clay, yellow, and loam, black	40	40
Clay, blue, pebbly	60	100
Sand, water	10	110
Pennsylvanian system		
Pottsville		
Shale, gray	16	126

Log of deep well at Bushnell—Concluded

	Thickness *Feet*	Total depth *Feet*
Mississippian and Devonian systems		
Keokuk and Burlington		
Limestone, white, with some chert, and crystals of calcite	116	242
Limestone, white to gray, cherty, with segments of crinoid stems	83	325
Limestone, with white chert	84	409
Kinderhook and Upper Devonian systems		
Shale	201	610
Shale, brown	20	630
Shale, blue	20	650
Devonian and Silurian systems		
Limestone, gray, soft	30	680
Limestone, brown to gray	30	710
Limestone or dolomite, blue	15	725
Dolomite, white, crystalline, cherty, with a few sand grains	7	732
Sand, in rounded, white quartz grains	8	740
Ordovician system		
Maquoketa		
Shale, blue	38	778
Shale, brown	20	798
Shale, blue, calcareous	16	814
Shale, black	16	830
Shale, blue and brown	33	863
Shale and dolomite	32	895
Galena-Platteville		
Dolomite, yellow to brown	178	1073
Dolomite, gray	70	1143
Dolomite, brown	72	1215
St. Peter		
Sandstone, white, rounded grains	140	1355

The following log was compiled from the study of samples of rock drillings, and the driller's record of a well put down for oil in the NW.¼ NW. ¼ sec. 34, T. 9 N., R. 3 W. (Ellison) in Warren County.

Log of oil well in NW. ¼ sec. 34, T. 9 N., R. 3 W. (Ellison)

Altitude of the surface 752 feet

	Thickness *Feet*	Total depth *Feet*
Quaternary system		
Soil and clay (probably loess)	25	25
Clay, blue	10	35
Shale, or clay	5	40
Sand	2	42

Log of oil well in sec. 34, T. 9 N., R. 3 W.—Concluded

	Thickness	Total depth
Pennsylvanian system	*Feet*	*Feet*
Pottsville		
Shale	28	70
Sand	4	74
Shale, blue	36	110
Limestone	6	116
Shale, blue	46	162
Limestone	2	164
Shale	5	169
Mississippian system		
Burlington		
Limestone	20	189
Shale	2	191
Limestone	131	322
Kinderhook		
Shale, light	118	440
Devonian system		
Upper Devonian (Sweetland Creek)		
Shale, brown to black	10	450
Shale, drab, with spores of *Sporangites huronense*	105	555
Devonian and Silurian systems		
Limestone, gray, dolomitic	10	565
Limestone, gray, non-dolomitic	35	600
Limestone, dark	20	620
Dolomite, gray	42	662
Ordovician system		
Maquoketa		
Shale, light	12	674

Another oil well from which samples of drillings were studied by a member of the State Geological Survey, was put down on the D. H. Gochenour farm in sec. 3, T. 6 N., R. 5. W. (Fountain Green). The log of this well is given below, with interpretations by T. E. Savage.

Log of oil drilling in sec. 3, T. 6 N., R. 5 W.

Altitude of the surface 660 feet

	Thickness	Total depth
Quaternary system	*Feet*	*Feet*
Soil, clay, and gravel	30	30
Mississippian system		
St. Louis, Salem, and Warsaw		
Limestone and shale	85	115
Burlington and Keokuk		
Limestone, leached, with chert fragments	45	160
Limestone, white, crystalline, with much chert	90	250
Limestone, white, crystalline, with little chert	75	325
Limestone with some greenish, sandy shale	30	355
Kinderhook		
Shale, greenish to gray	45	400
Shale, greenish to gray, calcareous	80	480

Log of oil drilling in sec. 3, T. 6 N., R. 5 W.—Concluded

	Thickness *Feet*	Total depth *Feet*
Devonian system		
Upper Devonian (Sweetland Creek)		
Shale, greenish, and dark fragments, the latter containing numerous spores of *Sporangites huronense*	100	580
Devonian and Silurian systems		
Dolomite and limestone, gray, subcrystalline, with pyrite	40	620
Limestone, gray, with chert fragments, mostly fine grained	110	730
Dolomite, gray to drab, with small quartz sand grains	15	745
Ordovician system		
Maquoketa		
Shale, bluish-gray	10	755

Rocks Not Exposed

CAMBRIAN SYSTEM

UPPER CAMBRIAN ("POTSDAM") SANDSTONE

From the foregoing logs of deep wells it will be seen that the oldest rocks explored in the Good Hope and La Harpe quadrangles belong to the Upper Cambrian series, which has been called the "Potsdam" or Croixan sandstone. Although this sandstone was penetrated to a depth of 296 feet, its base was not reached, and the total thickness of the formation in this area is therefore not known. In other places in Illinois deep wells have been drilled into this sandstone to a depth of 1,000 feet without reaching the bottom, and it is probable that a comparable thickness is present in this region. Sandstones of Upper Cambrian age are an important source of artesian water in many of the deep wells in northeastern Illinois. In central Wisconsin where these sandstones immediately underlie the surficial materials, and receive their water, the total thickness reported is about 1,000 feet. The Upper Cambrian sandstone in this and adjacent regions was deposited on a planed and eroded floor of pre-Cambrian crystalline or metamorphic rocks. In places in the eastern and western parts of the continent the Middle Cambrian underlies the Upper Cambrian, and in still other places in these regions both the Lower and the Middle Cambrian rocks intervene between the Upper Cambrian sandstone and the crystalline rocks of pre-Cambrian age.

The Upper Cambrian strata penetrated in the Good Hope and La Harpe quadrangles consist of sandstone composed of medium to coarse quartz grains. This sand was largely derived from the areas of pre-Cambrian rocks in northern Wisconsin and Minnesota that were above the sea and undergoing weathering and erosion during the time the strata here were accumulating. These detrital sands were carried by the streams from the land surface to the sea where the waves spread them widely over the entire surface of Illinois and the greater part of the Mississippi valley which at that time was submerged nearly as far north as central Wisconsin. This sand was subsequently consolidated into sandstone by the precipitation of iron oxide or silica between the grains, cementing them more or less firmly together.

ORDOVICIAN SYSTEM

"LOWER MAGNESIAN" LIMESTONE

By the time the last of the Potsdam sandstone was deposited, the lands bordering this region had become worn down so nearly to a plain or base level that the streams carried little sediment to the sea. In the clear seas of this stage, which is called "Lower Magnesian," there flourished marine animals of various kinds which secreted calcareous shells. After the death of the animals the shells were more or less broken up by the waves, and the fragments later were cemented together into limestone by the precipitation of calcium carbonate in the spaces between them. During the "Lower Magnesian" period of deposition the accumulation of mechanical sediments as sands and muds recurred temporarily at a few different times; but much the greater part of these strata consist of what were originally limestones, most of which have subsequently been more or less completed altered to dolomite by the partial replacement of the calcium of the limestone by magnesium. These rocks are the oldest that are exposed in the State. The area of their outcrop in Illinois is confined to patches in La Salle, Ogle, and Lee counties, and during low water also in the lower part of the bank of Mississippi River for a short distance north of the Cap au Gres fault, in Calhoun County.

From the fact that the "Lower Magnesian" limestone includes the earliest extensive deposit of dolomite or magnesian limestone in the Mississippi valley, these rocks were referred to by Owen, and the earlier geologists, as the "Lower Magnesian" limestone. The total thickness of this limestone in the only drilling that passed through it in the quadrangles is 274 feet. Farther north the thickness increases, the average thickness in northern Illinois being between 300 and 400 feet.

Accumulation of the calcareous matter of the "Lower Magnesian" limestone was stopped by the withdrawal of the sea from this entire region, and was followed by a prolonged period of land conditions, with attendant weathering and erosion of the exposed surface of this and older formations.

ST. PETER SANDSTONE

The sea again returned over this region while the surface still possessed considerable relief. Differences in the elevation of the top of the "Lower Magnesian" limestone of 100 feet in a horizontal distance of less than one-fourth mile, have been reported. These differences were caused mainly by erosion of the limestone previous to St. Peter deposition, and resulted in corresponding differences in the thickness of the St. Peter sandstone, which is thickest over the old valleys in the "Lower Magnesian" limestone. During St. Peter time the lands bordering this basin were relatively higher than they were when the "Lower Magnesian" limestone was deposited, so that erosion was more active, and the streams carried large quantities of sand. The source of this sand was the relatively high areas of crystalline rock exposed farther north in Wisconsin and Minnesota, and also the bordering areas over which the Potsdam sandstone was then exposed at the surface.

The St. Peter sandstone consists of remarkably clean and well-sorted, rounded quartz grains which, except where it is more or less case-hardened on exposed surfaces, is often so incoherent that it can be dug with a shovel. In Illinois it is best exposed in the vicinity of Utica and La Salle, in La Salle County, where it is quarried extensively for use in the manufacture of glass. The canyons in Starved Rock and Deer Park have been cut in this sandstone.

On account of the perfectly sorted and rounded character of the sand grains, Berkey[1] and Grabau[2] have assumed that the St. Peter sandstone was deposited by the winds under desert conditions. However, the rather irregular stratification of the sand, and the presence in it in some places of casts of marine shells makes it seem more probable that it was deposited in a shallow sea where the winds and waves shifted the sands back and forth for long distances over wide beaches, the prolonged suspension and movement of the sediment accomplishing the unusually thorough sorting of the sand, and rounding of the grains.

The St. Peter sandstone is one of the most important sources of deep well water in the State. Its thickness in the only well that passed through it in the quadrangles is 196 feet. In another well the formation was penetrated 140 feet without passing through it. Its thickness in northern Illinois varies from 60 feet or less to more than 200 feet. The average thickness in this immediate region is about 175 feet.

GALENA-PLATTEVILLE LIMESTONE

Deposition of the Galena-Platteville limestone strata succeeded that of the St. Peter sandstone after a short break. The lower part of the Platteville in this region usually contains a variable thickness of shale, but later limestone accumulation became dominant and persisted without long interruptions until the time of general sea withdrawal at the close of the Galena. The Platteville is usually a fine-grained non-magnesian limestone, 50 to 70 feet thick, with more or less shale; while the overlying Galena formation was originally a limestone that has almost everywhere been altered to a dolomite, and has a thickness of about 250 feet. This dolomite includes the lead and zinc deposits of northwest Illinois, and adjacent portions of Wisconsin and Iowa. The recognized boundary between the Galena and Platteville is not so clearly a stratigraphic as a lithologic one, although, in some places at least, a slight unconformity appears to be present between them.

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[1] Berkey, Chas. P., Paleogeography of St. Peter time: Geol. Soc. of America Bull., Vol. 17, pp. 229-250, 1906.

[2] Grabau, Amadeus W., Principles of Stratigraphy: p. 569, 1913.

The base of what is called the "oil rock," which consists of one or more thin bands of bituminous shale, is usually considered the base of the Galena formation. Beneath this "oil rock" farther north there occurs a thin shale, normally 1 to 3 feet thick in Illinois, that has been taken as the upper member of the Platteville. In northeast Iowa this shale horizon is in places much thicker, and has been referred to by Calvin[1] as the Decorah shale.

In the logs of the wells in the Good Hope and La Harpe quadrangles neither the horizon of this shale nor of the overlying "oil rock" has been distinguished, hence no attempt is made to separate the Galena from the Platteville in the generalized columnar section of the rocks of this area.

Farther south in Illinois and adjacent portions of Missouri the rocks that correspond in position to the Galena and Platteville formations are known respectively as the Kimmswick and Plattin limestones. These formations are both calcium carbonate (non-dolomitic) throughout and present such differences in fossils as well as lithology from the Galena and Platteville limestones in the north part of the State, that they are thought to have been deposited in a basin more or less completely separated from that in which the Galena and Platteville limestones accumulated.

MAQUOKETA SHALE

A long period of land conditions in this region followed the deposition of the Galena limestone. This was interrupted by a submergence in the latter part of the Cincinnatian epoch during which the Maquoketa beds were laid down. During this submergence large quantities of mud at times more or less calcareous and at others sandy were spread over this region and later became consolidated into shale, largely by pressure of the weight of overlying sediments. The thickness of this shale in the wells that passed through it in the quadrangles is 165 feet. In other parts of the State its thickness ranges from 50 to more than 200 feet. It rests unconformably upon the eroded surface of the Galena and Kimmswick limestones and is separated from the overlying Silurian strata by a similar indication of a break in sedimentation. Farther north in Illinois the upper part of the Maquoketa consists of a very fossiliferous, somewhat shaly limestone; while in Will County and other places in the northeast part of the State a bed of limestone is also present in the basal part of the formation. In the southwest part of Illinois the rocks of this time include two members, the Fernvale, a thin, rather pure limestone, below, and the Thebes sandstone, a rather fine-grained sandstone, the two separated by a conspicuous unconformity. The Maquoketa strata in this region and in the upper Mississippi valley correspond in time to some part of the Richmond beds of the Ohio valley, in Indiana, Ohio, and Kentucky. The widespread sea withdrawal that occurred at the end of the Maquoketa marks the end of the Ordovician period.

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[1] Calvin, Samuel, Geology of Winnishiek county: Iowa Geol. Survey, Ann. Rep., 1905, Vol. 16, pp. 84-87, 1906.

SILURIAN SYSTEM

Deposition of Early Silurian sediments in Illinois occurred in an embayment of the sea that extended northward from the Gulf of Mexico region during a time when the larger part of the continent was above sea level and receiving no marine deposits. The Orchard Creek shale and Girardeau limestone were laid down over a small area near Thebes. The Edgewood formation was deposited unconformably above the Girardeau limestone which it overlapped on the north, extending in this direction as far as Carroll County, and towards the northeast as far as Custer Park, Essex, Channahon, Oswego, and Belvidere, near which place patches of these deposits 12 to 25 feet thick are known to be present. In most places the Edgewood formation rests upon Maquoketa shale, but near Belvidere it seems to transgress the Maquoketa, and rest directly upon the Galena limestone. The Edgewood strata commonly consist largely of yellowish-brown magnesian limestone which, near Channahon, in Will County, rests upon a thin-bedded, rather fine-grained sandstone a few feet thick, which corresponds in position to the Hoing sand of this region.

At the close of Edgewood time the sea withdrew, and during the following emergence the Edgewood rocks were eroded to such an extent that only a few disconnected patches or outliers remain to indicate the former extent of this formation. The disconnected areas of sand lying just above the Maquoketa, known as the Hoing sand, which is the source of oil in the Colmar and western Illinois fields, is thought to represent patches of the basal Edgewood sandstone in this region, the Edgewood limestone that originally overlaid the sandstone having been removed by erosion before the sea again covered the region. Patches of this sandstone are present beneath the Silurian limestone in a few places in the Good Hope quadrangle, as at Bushnell, and in many other places in western Illinois.

The sea that next covered parts of Illinois advanced from the south as far as Jackson County, and deposited the Sexton Creek limestone which has a thickness of 50 to 70 feet. About the same time another sea invasion from the east or northeast extended as far as Calhoun and Jersey counties, Illinois. In this basin there accumulated a thickness of 40 or 50 feet of relatively pure non-magnesian limestone. This has been called the Kankakee limestone, from the river of that name along the banks of which it is well exposed a few miles above Custer Park. This limestone was spread over the eroded surface of the Edgewood, and in many places where the latter had been entirely eroded, as in the vicinity of Elgin and St. Charles, it rests upon the Maquoketa shale. Compared with the younger Niagaran rocks which are almost everywhere dolomitic, the Kankakee limestone is in places non-magnesian, more gray in color, and commonly more fossiliferous. In the drillers' logs it is often impossible to distinguish whether the limestone next above the Maquoketa shale or the Hoing sand, is the Kankakee limestone or the Niagaran dolomite, as both are reported as limestone. In the few wells in the quadrangles from which samples of drillings have been studied this rock is dolomite, and the Kankakee limestone appears to be absent. However, samples of drillings from some of the oil wells in areas farther south indicate a non-dolomitic limestone immediately above the Maquoketa shale or Hoing sand, and the nearest outcrop of Silurian limestone to this area is that of the Kankakee limestone in the bank of Mississippi River in Pike County. Consequently it is probable that patches of the Kankakee limestone are in places present in the La Harpe and Good Hope quadrangles.

The Niagaran limestone, which succeeds the Kankakee in apparent unconformity, is a yellowish dolomite that accumulated in a clear sea in which corals and other marine animals flourished in great abundance. It probably originally extended over the greater part of Illinois, north of the latitude of St. Louis. The thickness of the Niagaran where it has been differentiated from the Devonian in the quadrangles ranges from 20 to 40 feet, but the average thickness in northern Illinois is near 300 feet. The original thickness in the quadrangles was probably not less than the average for the State. It rests in places unconformably upon some horizon of the Edgewood or the Kankakee limestone, or where these were entirely eroded it overlies the irregularly eroded surface of the Maquoketa shale. Following the deposition of the Niagaran limestone, the sea withdrew from Illinois and the greater part of the Mississippi valley. Land conditions prevailed over this particular region during the remainder of the Silurian, and the early and middle parts of the Devonian period. During this long interval weathering and erosion were active, the amount of denudation being limited mainly by the low altitude of the region above the sea. What thickness of Silurian rocks was removed from this region is not known, but it is probable that at least a few hundred feet, representing the difference between its present thickness in the quadrangles and the average thickness over northern Illinois, were eroded from the surface.

DEVONIAN SYSTEM

In early and middle Devonian time, marine sediments were deposited intermittently in southwest Illinois, as far north as Jackson county, resulting in the accumulation of an aggregate thickness of more than 700 feet of sediments. The central and northern parts of the State remained above the sea until the latter part of the Devonian period, when a sea advanced from the Arctic region nearly as far south as St. Louis, covering the Good Hope and La Harpe quadrangles. In this sea the water was generally clear and limestone accumulated in places in Illinois to a depth of 150 or more feet. The average thickness of this limestone in the wells of the quadrangles from which samples of drillings were studied is about 85 feet. Farther north, in the vicinity of Rock Island, and in Iowa, this limestone is separated into two formations: the Wapsipinicon limestone below, and the Cedar Valley limestone above, but these formations can not be differentiated in the well logs in the quadrangles.

After another emergence of considerable length, in late upper Devonian time, the northern sea returned over the larger part of Illinois, and spread upon the eroded surface of the Devonian limestone and older formations a deposit of dark mud which now forms the Sweetland Creek shale. This mud contained tiny spores of a fern-like plant, known as *Sporangites huronense,* in such numbers that scores of the undecomposed spore cases can now be found in almost every cubic centimeter of the shale. The thickness of the shale in the State ranges from a few to more than 200 feet. The average thickness in the wells of the Good Hope and La Harpe quadrangles from which samples of drillings were studied is about 125 feet.

MISSISSIPPIAN SYSTEM

KINDERHOOK SHALE

The oldest sediments belongings to the Mississippian system in this region constitute the Kinderhook formation. This formation consists almost entirely of shale in this area, but in some places in this and adjoining states it contains important quantities of sandy and calcareous material. In some places it was laid down upon the Sweetland Creek strata without apparent discordance, while in others these formations are separated by a distinct break in deposition. In the drillers' logs of borings the Kinderhook shale is not differentiated from the underlying Sweetland Creek, but in samples of drillings it can be readily distinguished by its lighter, greenish-gray color, and the absence of spores of *Sporangites huronense.* The average thickness of the Kinderhook in the three wells in which it could be differentiated from the Sweetland Creek, is 125 feet.

The muddy seas of Kinderhook time gradually became clear, and marine animals that secreted calcareous shells flourished in great numbers. The comminuted fragments of these shells became cemented into the Burlington limestone. Never before or since did crinoids grow in such profusion as on the bottom of the clear, shallow sea of Burlington time in this region. The thickness of this limestone in the deep wells of these quadrangles ranges from 60 to 220 feet. Over a considerable area in the north part of the quadrangles this limestone immediately underlies the glacial drift or the Pennsylvanian rocks, and its surface suffered extensive erosion between the time of deposition of the youngest of the Burlington and the oldest of the Pennsylvanian strata or the drift.

Rocks Exposed

MISSISSIPPIAN SYSTEM

BURLINGTON LIMESTONE

Outcrops of Mississippian rocks in the area under consideration are confined to the La Harpe quadrangle. The oldest formation well exposed in this area is the Burlington limestone, outcrops of which are confined to a few square miles in the north part of the La Harpe quadrangle, along the banks of Ellison and Honey creeks, and their branches.

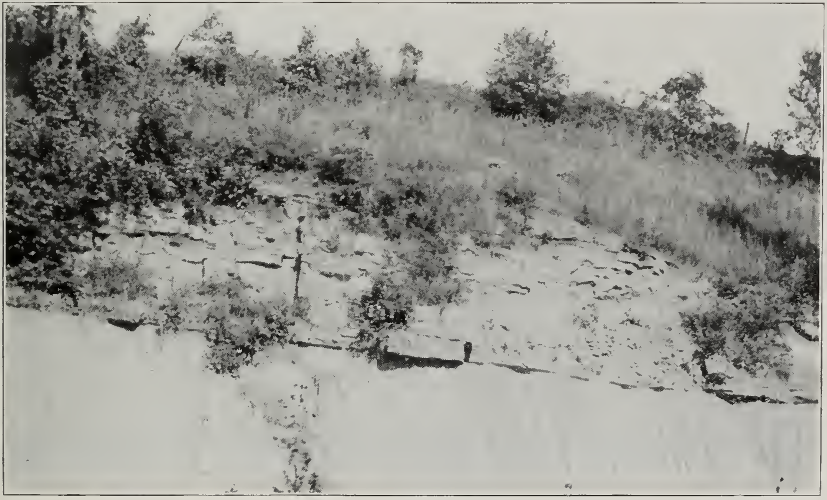

Fig. 2. Contact of the Kinderhook shale and Burlington limestone in NE. ¼ sec. 24, T. 9 N., R. 4 W. (Media Twp.), in the bank of Ellison Creek, La Harpe quadrangle.

The contact of the Burlington and the underlying Kinderhook is well exposed along Ellison Creek in the NE. ¼ sec. 24, in Media Township (T. 9 N., R. 4 W.), where the following section and the photograph reproduced as figure 2 were made:

Section of strata along Ellison Creek in sec. 24, T. 9 N., R. 4 W. (Media)

	Thickness	
	Ft.	In.
Burlington limestone		
Limestone, gray, crinoidal, fossiliferous, in thick layers which contain more or less chert	12	..
Kinderhook shale		
Sand, fine-grained	..	1
Shale, soft, bluish-gray	19	..

The top of the Kinderhook shale at this place dips gently toward the north. A few rods southeast of the last exposure the Burlington-Kinderhook contact is again exposed in the banks of a small tributary joining Ellison Creek on the south. A section of these strata is as follows:

Section of strata along a small tributary to Ellison Creek in the NE. ¼ sec. 24, T. 9 N., R. 4 W. (Media)

	Thickness
	Feet
Burlington limestone	
Limestone, light-gray, crinoidal and crystalline, cherty; with many fossils	36
Kinderhook shale	
Shale, greenish-gray	1

Strata representing the lower part of the Burlington are also exposed in the E. ½ sec. 13, Media Township (T. 9 N., R. 4 W.), and in the SW. ¼ sec. 19, Ellison Township (T. 9 N., R. 3 W.). The species of fossils listed below were found in the Burlington limestone at localities above mentioned:

Fossils from the lower part of the Burlington limestone in secs. 13 and 24, Media Township (T. 9 N., R. 4 W.), and sec. 19, Ellison Township (T. 9 N., R. 3 W.)

Zaphrentis sp.
Hydrophyllum glans
Granatocrinus norwoodi
Dizygocrinus rotundus
Macrocrinus verneuilianus
Platycrinus sp.
Productus burlingtonensis
Productus viminalis
Rhipidomella burlingtonensis
Schizophoria swallovi
Spirifer grimesi
Spirifer incertus
Spirifer cf. imbrex
Spirifer sp.
Athyris lamellosa
Cleiothyridina incrassata
Metoptoma umbella

In both banks of a small ravine near the middle of the south side of sec. 21, Media Township (T. 9 N., R. 4 W.), weathered masses of cherty, crinoidal limestone, which doubtless belong in the basal part of the Burlington, are exposed to a maximum thickness of 12 to 15 feet. Corresponding strata were formerly quarried in the SE. ¼ sec. 19, of the same township.

A somewhat higher level in the Burlington limestone is well exposed for a distance of several rods in the banks of Honey Creek, in the NW. ¼ sec. 3, Terre Haute Township (T. 8 N., R. 5 W.). As elsewhere in the region this limestone is coarsely crystalline, crinoidal, very fossiliferous, and contains considerable chert in the form of concretions and discontinuous bands. The total thickness at this locality is about 12 feet. The fossils named below were taken from the limestone at this place:

Fossils from the Burlington limestone in sec. 3, T. 8 N., R. 5 W.
(Terre Haute)

Zaphrentis centralis
Zaphrentis sp.
Granatocrinus norwoodi
Dizygocrinus rotundus
Eutrochocrinus christyi
Batocrinus sp.
Platycrinus sp.
Fenestella sp.
Productus burlingtonensis
Chonetes illinoisensis
Rhipidomella burlingtonensis
Dielasma osceolensis
Spirifer grimesi
Spirifer incertus
Spiriferella plena
cf. Brachythyris suborbicularis
Reticularia sp.
Cleiothyridina incrassata
Metoptoma umbella

Similar limestone strata which also contain a fauna similar to that listed above is exposed in the banks of a branch of Honey Creek in the SE. ¼ sec. 8, Terre Haute Township (T. 8 N., R. 5 W.), to a total thickness of 18 feet. In the SE. ¼ sec. 4 of the same township the Burlington limestone outcrops in both banks of Honey Creek, and good exposures also occur in the banks of a tributary to Honey Creek, in the SW. ¼ sec. 17, Terre Haute Township (T. 8 N., R. 5 W.).

KEOKUK LIMESTONE

On the geological map of the La Harpe quadrangle the boundary between the Burlington and the Keokuk limestones has not been shown because the small number of outcrops of the latter give too little information regarding its distribution. The Keokuk limestone probably overlies the Burlington over the larger part of the quadrangles except in the northern part of the Good Hope area where the Burlington immediately underlies the surficial material. Deposition of Burlington time continued without interruption and the Keokuk rests conformably upon the Burlington limestone in this region. However, slight movements occurred at this time which resulted in the southward retreat of the sea for a few miles, and a slight uplift of the bordering lands which increased the mud sediment carried by the streams that discharged into this basin. Compared with the Burlington limestone, the Keokuk is usually darker or bluish in color and more argillaceous, containing shaly layers which are more numerous in the upper part. The thickness of the Keokuk limestone at Keokuk is about 75 feet, and its maximum thickness in the quadrangles is probably less than that figure.

Outcrops of Keokuk limestone in the quadrangles are limited to the western part of the La Harpe area. The best exposures occur in the banks of Dugout Creek in the SW. ¼ sec. 29, Terre Haute Township (T. 8 N., R. 5 W.). This limestone also outcrops a little farther down the creek, in the SE. ¼ sec. 30, of the same township. The maximum thickness seen at these localities was 13½ feet. This limestone is yellowish, thin-bedded, somewhat shaly, and more or less crinoidal. It furnished the fossils listed below:

Fossils from the Keokuk limestone along Dugout Creek in the SW. ¼ sec. 29, T. 8 N., R. 5 W. (Terre Haute)

Zaphrentis centralis
Zaphrentis dalei
Dorycrinus sp.
Cystodictya sp.
Fenestella sp.
Lioclema cf. gracillens
Archimedes negligens
Archimedes owenana
Orthotetes keokuk
Productus cf. magnus
Productus setigerus
Productus wortheni
Pustula alternata
Dielasma sinuata
Spirifer keokuk
Spirifer logani
Spirifer tenuicostatus
Spirifer sp.
Brachythyris suborbicularis
Reticularia pseudolineata
Eumetria sp.
Athyris sp.
Myalina keokuk
Cypricardinia sp.
Griffithides cf. portlocki

A short distance north of the La Harpe quadrangle, near the center of E. ½ sec. 19, Ellison Township (T. 9 N., R. 3 W.), an outcrop of badly weathered, cherty limestone furnished the following species of fossils: *Batocrinus sp., Orthotetes keokuk, Spirifer keokuk, Spiriferella cf. neglecta, Reticularia pseudolineata,* and *Athyris lamellosa.* A few miles northwest of the last locality, near the center of sec. 3, Media Township (T. 9 N., R. 4 W.), a small outcrop of cherty and somewhat shaly limestone, with occasional small geodes, furnished the characteristic Keokuk fossils named below:

Fossils from near the center of sec. 3, Media Township (T. 9 N., R. 4 W.)

Fistulipora sp.
Pustula alternata
Tetracamera subtrigona
Rhynchopora bucheri
Dielasma sp.
Brachythyris suborbicularis
Athyris lamellosa

WARSAW FORMATION

The conditions of sedimentation that had developed in late Keokuk time in this region continued without much change into the Warsaw. At times the sea cleared sufficiently for marine animals to flourish, and bands of calcareous matter to accumulate, but mud continued to be the dominant type of sediment. The Warsaw formation consists for the most part of rather soft, bluish, unfossiliferous shale, with occasional layers of shaly limestone and sandstone. The thickness at Warsaw, the type locality a few miles southwest of the quadrangles, is about 40 feet, which is more than twice the thickness of this formation in the Good Hope and La Harpe area. In well records in the quadrangles the Warsaw could not be separated from the overlying Salem which it resembles in lithological characters. The formation contains so little resistant rock that good exposures of the strata are few.

Outcrops of the Warsaw are restricted to the banks of La Harpe Creek and its branches, in the southwest quarter of the La Harpe quadrangle. The best exposure found is on La Harpe Creek in the SE. ¼ sec. 17, Fountain Green Township (T. 6 N., R. 5. W.), the detailed section of which is as follows:

Section of Warsaw strata in the SE. ¼ sec. 17, Fountain Green Township (T. 6 N., R. 5 W.)

	Thickness	
	Ft.	*In.*
Till, yellow	6	..
Shale, sandy, yellow	6	..
Sandstone, thin-bedded, soft, yellow	2	6
Shale, gray, soft	4	..
Sandstone, yellow, calcareous, in rather thick layers	4	..
Shale, soft gray	2	8
Limestone gray, thin-bedded, with a few impressions of *Bryozoa*	1	..

Another locality where shale thought to represent the Warsaw formation is exposed, is in the bank of Little Creek in the NW. ¼ sec. 3, T. 6 N., R. 5 W. (Fountain Green). This shale is bluish-gray, rather soft, in places sandy, and at certain levels somewhat calcareous. An aggregate thickness of 15 feet is present above an altitude of 602 feet, although some parts of this thickness are concealed. Farther up these creeks shale and sandstone representing the Salem formation appear above the Warsaw shale horizon.

SALEM FORMATION

The Salem formation which farther south in the State is usually a limestone, in this region consists chiefly of shale and sandstone, with a subordinate amount of limestone. The exposures are confined to the same general area as those of the Warsaw, from which, in the absence of fossils, these sediments can not always be satisfactorily distinguished. An outcrop of Salem strata occurs in the west bank of La Harpe Creek, in the NW. ¼ sec. 9, Fountain Green Township (T. 6 N., R. 5 W.), where the following section and accompanying photograph (Fig. 3) were made:

Section of strata in the bank of La Harpe Creek in sec. 9, Fountain Green Township (T. 6 N., R. 5 W.)

	Thickness *Ft.*	 *In.*
Till, yellow, with sandstone and shale fragments	6	..
Shale, soft, gray	..	6
Limestone, brown, sandy, containing shells of *Endothyra baileyi*	2	8
Shale, bluish-gray, soft, with lenses of calcareous sandstone	8	..
Limestone, shaly, with grains of quartz sand	2	4
Sandstone, coarse-grained, calcareous; grading laterally into a sandy limestone	1	..

About one-third of a mile farther down this creek, and in the opposite bank, the unconformable contact of the Salem formation and the overlying St. Louis limestone may be seen, as described in the detailed section below:

Section of strata in the SW. ¼ sec. 9, Fountain Green Township (T. 6 N., R. 5 W.)

	Thickness *Feet*
St. Louis limestone	
Limestone, white, brecciated	5
Salem formation	
Shale, gray; with sandy, calcareous bands	7
Limestone, gray, subcrystalline, sandy, with shells of *Endothyra baileyi*	1
Shale, gray; with lenses of sandy limestone	2
Concealed	3
Sandstone, calcareous, in rather thick layers	2

About one-half mile northwest of the locality last mentioned, the contact of the Salem and St. Louis strata is exposed in a branch of La Harpe

Creek not far from the middle of the west side of sec. 9 of the same township. The section at this place is as follows:

Section of strata in a branch of La Harpe Creek, near middle of west side of sec. 9, Fountain Green Township (T. 6 N., R. 5 W.)

	Thickness	
St. Louis limestone	*Ft.*	*In.*
Limestone, light gray, cherty, brecciated	20	..
Shale, soft, greenish-gray	..	6
Salem formation		
Shale, and sandy limestone	6	..

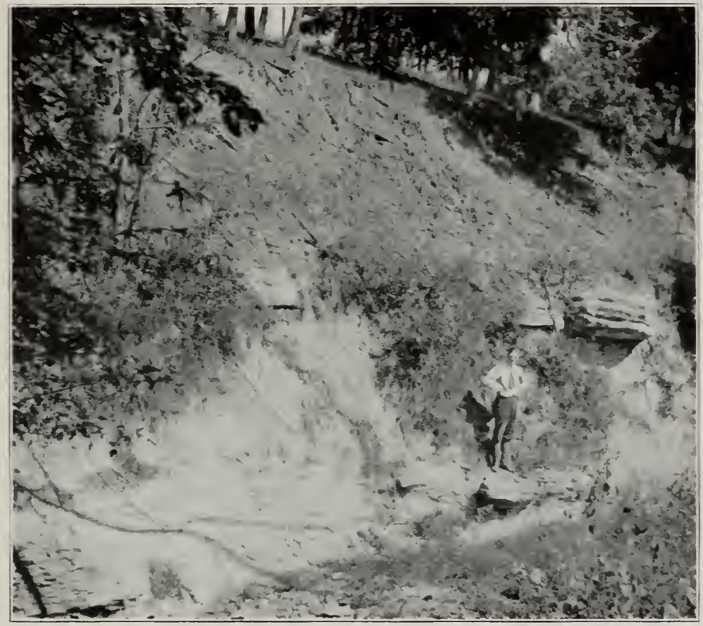

FIG. 3. Salem limestone and shale on La Harpe Creek in the NW. ¼ sec. 9, T. 6 N., R. 5 W. (Fountain Green Twp.).

The St. Louis limestone at this locality is conspicuously undulating (fig. 4), while the underlying Salem beds are nearly horizontal, so that the plane of contact of these formations presents a very uneven surface that can be traced up the stream for a distance of 100 yards or more.

ST. LOUIS LIMESTONE

A temporary sea withdrawal followed the deposition of the Salem beds and when the sea next returned over this region during St. Louis time the water was prevailingly clear so that limestone sediments accumulated. The submergence in the Mississippi valley during St. Louis time was more widespread than at any time since the Kinderhook, the sea covering all of this region and extending north as far as northern Iowa. The St. Louis is the youngest Mississippian formation present in the quadrangles. These strata are exposed in the area only in the southwest quarter of the La Harpe quadrangle, being mostly confined to Fountain Green Township where they unconformably overlie the Salem beds. They consist mostly of limestone which is usually fine-grained, more or less brecciated, irregularly bedded, cherty, and blotched with a greenish mineral, probably glauconite. In some places bands or lenses of greenish shale are present at the base and also at different levels in this limestone. The thickness is greatest towards the south in the type region in the vicinity of St. Louis where it exceeds 300 feet. In the La Harpe quadrangle the maximum known thickness is probably less than 35 feet. Exposures showing the lower part of the St. Louis unconformably overlying the Salem have been described on a previous page. A short distance west of the wagon road in the NE. ¼ NW. ¼ sec. 17, Fountain Green Township (T. 6 N., R. 5 W.), an outcrop rather typical of the St. Louis in this region occurs in the banks of a tributary of La Harpe Creek where the following section was made:

Section of St. Louis strata in the NW. ¼ sec. 17, T. 6 N., R. 5 W. (Fountain Green)

	Thickness *Feet*
Limestone, white, brecciated	3
Concealed	3
Limestone, impure, weathering brown, in rather thick layers	6
Limestone, brecciated, weathered brown, containing some chert	3

No fossils were found in these limestones. In places thin bands of bluish or greenish shale and white sand were present as partings or lenses in the limestone bed. The altitude of the base of the section above is 612 feet.

A thickness of 12 or 15 feet of St. Louis limestone outcrops near the middle of the NE. ¼ sec. 17 of the same township. This was mostly gray and brecciated, containing some chert and bands of greenish shale and sandstone similar to the limestone in the outcrop last described. It also furnished a species of coral belonging to the genus *Syringopora*.

Along a branch of Rock Creek in the NE. ¼ sec. 22, Fountain Green Township (T. 6 N., R. 5 W.), a thickness of 12 feet of white, brecciated St. Louis limestone overlies about 6 feet of brown, weathered and shattered, impure limestone containing veins of greenish shale. Specimens of *Zaphrentis sp.* and *Syringopora sp.* were also found at this place. About one-fourth mile farther up this stream gray limestone belonging to the St. Louis formation is exposed at the wagon bridge to an altitude 30 feet higher than the base of the limestone in the preceding outcrop. Weathered portions of the limestone at the wagon bridge contain irregular spherulites composed of radiating groups of filiform crystals of calcite, resembling in some respects the structure of the cone-in-cone bodies so common in the Pottsville of northwestern Illinois. One-half mile south of the locality last described, in the NW. ¼ sec. 23, the upper layers of the St. Louis are exposed beneath the Pottsville sandstone. The sequence of rocks is as follows:

Section of strata exposed in the NW. ¼ sec. 23, T. 6 N., R. 5 W.
(Fountain Green)

	Thickness	
	Ft.	*In.*
Pottsville formation		
Sandstone, coarse, micaceous, in places somewhat conglomeratic	1	..
Coal blossom	..	1½
Sandstone, coarse, micaceous, with fragments of bituminous matter; rests on an uneven, eroded surface of limestone	..	6
St. Louis limestone		
Limestone, brown, with chert nodules	1+	..
Limestone, white, brecciated	10	..

The altitude of the top of the limestone at this place is about 631 feet. Nearly the entire thickness of the St. Louis is exposed in the sections above described in secs. 22 and 23, Fountain Green Township (T. 6 N., R. 5 W.).

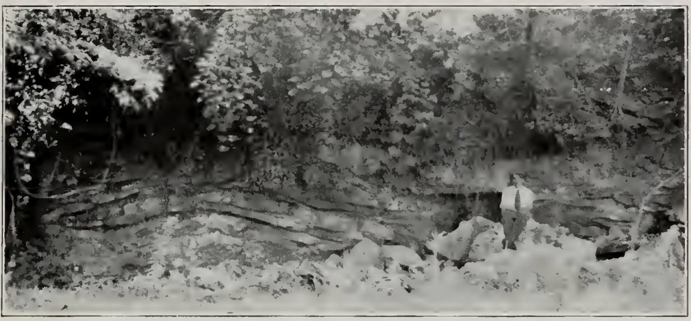

FIG. 4. Undulating and brecciated St. Louis limestone exposed in La Harpe Creek in the NW. ¼ sec. 9, T. 6 N., R. 5 W. (Fountain Green Twp.).

The contact of the St. Louis and Pottsville may also be seen farther east on the banks of Baptist Creek, in the NW. ¼ sec. 7, in Hire Township (T. 6 N., R. 4 W.) as shown in the following section:

Section of strata in the NW. ¼ sec. 7, Hire Township
(T. 6 N., R. 4 W.)

	Thickness	
	Ft.	*In.*
Pottsville formation		
Sandstone, thin-bedded, gray	..	8
Shale, black	1	6
Coal	..	7
Shale, gray	3	..
Sandstone	4	..
Shale	2	6
St. Louis limestone		
Limestone, weathered	3+	..

The altitude of the top of the limestone is about 607 feet. The top of the St. Louis limestone is also exposed about three-fourths of a mile northeast of the locality last described at an elevation of about 628 feet.

The contact of the St. Louis and Pottsville formations is exposed again along a branch of La Harpe Creek in the NE. ¼ sec. 4, Fountain Green Township (T. 6 N., R. 5 W.), as shown in the following section:

Section of strata exposed in NE. ¼ sec. 4, T. 6 N., R. 5 W.
(Fountain Green)

	Thickness	
	Ft.	*In.*
Pottsville formation		
Sandstone	4	..
Sandstone, in places passing laterally into conglomerate with chert and limestone pebbles in a sandstone matrix	2	..
Shale, present in only a few places	..	4
St. Louis limestone		
Limestone, gray, fine-grained, in places strongly brecciated, and containing one or two irregular bands of calcareous shale 1 to 12 inches thick	32	..

The altitude of the top of the limestone at this place is about 661 feet. The limestone is unfossiliferous, but contains structureless globular bodies coated with a green mineral. The surface of the limestone is in places very uneven.

A thickness of 8 or 10 feet of gray, cherty, strongly brecciated St. Louis limestone, in irregular layers which contain *Lithostrotion proliferum,* is exposed along a stream near the middle of the west half of sec. 6, Fountain Green Township (T. 6 N., R. 5 W.), about a mile west of the west border of the La Harpe quadrangle. The altitude of the top of this limestone is about 620 feet.

In the several exposures of St. Louis limestone in this region the strata appear to lie nearly horizontal. A southward dip of about 10 feet per mile is indicated by the difference in altitude of the top of the St. Louis in the NE. ¼ sec. 4, Fountain Green Township (T. 6 N., R. 5 W.), and the NW. ¼ sec. 23, of the same township. However, the fact that the top of the St. Louis is an erosion surface may account for a part of the difference in altitude of the top of this limestone in the different exposures in the area.

PENNSYLVANIAN SYSTEM

In this portion of the Mississippi valley a long period intervened between the deposition of the youngest strata of the Mississippian system and the oldest layers of the overlying Pennsylvanian. All of the upper Mississippian (Chester) and the St. Genevieve—rocks which in southern Illinois have a combined maximum thickness of more than 800 feet—are wanting. Even where these are present in the southern part of the State the time interval represented by the unconformity between the Chester and Pennsylvanian is very long.

POTTSVILLE FORMATION

The Pottsville formation as defined in Illinois includes that part of the Pennsylvanian rocks between the top of the Mississippian and the base of the shale underlying the Murphysboro (No. 2) coal. These strata are variable and consist largely of shales, often more or less sandy, with smaller amounts of sandstone, two or three thin beds of limestone, and three or four thin coal beds. This formation commonly rests unconformably upon the St. Louis limestone of the Mississippian system, but in places in the La Harpe quadrangle it appears to unconformably overlie the Salem, Warsaw, Keokuk, and Burlington formations respectively.

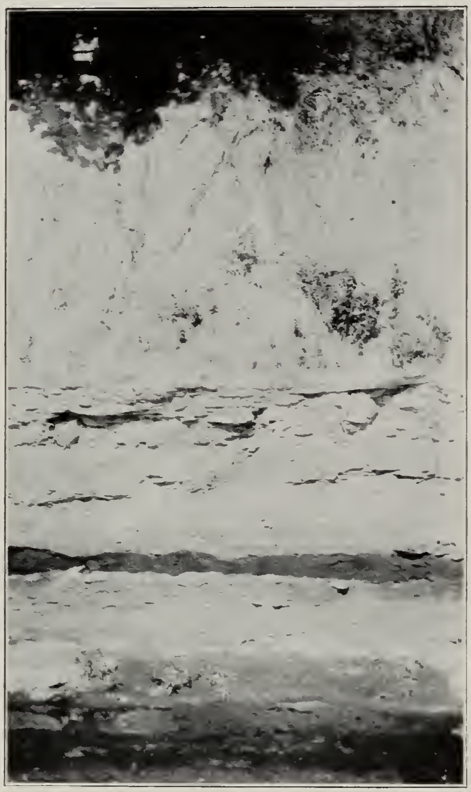

FIG. 5. Pottsville strata exposed on Baptist Creek in SW. ¼ sec. 6, T. 6 N., R. 4 W. (Hire Twp.).

Distribution and thickness.—Pottsville strata doubtless underlie the whole of the Good Hope quadrangle, and the greater part of the east half of the La Harpe. The best exposures of the formations in the La Harpe quadrangle are in the south central part, along Baptist and La Harpe creeks, and the south branch of Crooked Creek. In the Good Hope quadrangle the Pottsville rocks outcrop along Nigger and Swan creeks, and in the banks of Cedar Creek in the northeast quarter of the area. These strata immediately underlie the unconsolidated Pleistocene deposits over the greater part of the east half of the La Harpe quadrangle; and a small area in the northeast part and the most of the south quarter of the Good Hope area.

The thickness of the formation varies generally from 35 to 90 feet. The thickness is greatest in the north and east parts of the area in which the Pottsville rocks are overlain by younger Pennsylvanian strata.

Character of the Pottsville rocks.—The earliest Pottsville strata in the region consist in some places of a few feet of sandstone, sometimes including a sandy conglomerate in the basal part, and in other places of gray to dark shale. This basal shale or sandstone is usually overlain by 10 to 12 feet of shale which is often separated from the higher sandy shale bed by a thin coal. Above the upper sandy shale is a sandstone 5 to 8 feet thick, which is thin bedded in the lower part and at the top contains a sandstone layer with very numerous rootlets of stigmaria. Farther east in the Avon quadrangle, as in this region, the *Stigmaria* sandstone is separated from the Rock Island (No. 1) coal horizon by a few inches to 1 or 2 feet of shale. Above the Rock Island coal is, commonly, a hard, dark, fossiliferous limestone cap rock from a few inches to 6 to 12 feet thick.

The Rock Island (No. 1) coal is in many places absent and the limestone cap rock is often missing. Where present, the coal occurs 30 to 40 feet below the Murphysboro (No. 2) bed. The strata between these coals are mostly shales. The horizon of the stoneware clay of the Colchester region can be recognized in a few places, and commonly occurs about 15 to 20 feet below the Murphysboro (No. 2) coal. The general character of the Pottsville strata may be seen from the detailed descriptions contained in the following sections.

In the La Harpe quadrangle the best exposures of the Pottsville are in the eastern part of the southwest quarter of the area. Along the bed and banks of a stream in the NE. ¼ sec. 3, T. 6 N., R. 5 W., (Fountain Green) the contact of the Pottsville strata with the underlying St. Louis limestone is exposed:

Section of strata exposed in sec. 3, Fountain Green Township (T. 6 N., R. 5 W.)

	Thickness	
	Ft.	*In.*
Pottsville		
Sandstone, coarse-grained, yellowish brown	2	..
Conglomerate, sandy, with pebbles of chert and limestone	1	..
Shale, greenish	..	7
St Louis		
Limestone, fine grained, in irregular layers, in places brecciated; thin zones and lenses of greenish shale near the top	32	..

The elevation of the contact of the St. Louis and Pottsville at this place is about 672 feet. The contact of the Pennsylvanian and Mississippian rocks outcrops again along a stream in the NW. ¼ sec. 23 of Fountain Green Township (T. 6 N., R. 5 W.) where the following section was made:

Section of rocks outcropping in sec. 23, T. 6 N., R. 5 W. (Fountain Green)

	Thickness	
	Ft.	*In.*
Pottsville		
Sandstone, coarse, micaceous	1	..
Coal blossom	..	2
Sandstone, coarse, micaceous	..	6
St. Louis		
Limestone, brown, weathered, with chert nodules	1	..
Limestone, white, brecciated	10	..

In the NW. ¼ sec. 7, T. 6 N., R. 4 W. (Hire) the lower Pottsville and upper St. Louis strata are exposed beneath the glacial till in two or three places, as shown below:

Section of strata exposed in the NW. ¼ sec. 7, Hire Township (T. 6 N., R. 5 W.)

	Thickness	
	Ft.	*In.*
Pottsville		
Sandstone, gray, thin bedded	..	8
Shale, black	1	6
Coal	..	7
Shale, gray	3	..
Sandstone, coarse, yellowish-brown	4	..
Shale, greenish	1	6
St. Louis		
Limestone	3	..

The elevation of the base of the Pottsville at this place is about 614 feet.

Lower Pottsville rocks are well exposed (Fig. 5) in the north bank of Baptist Creek, in the SW. ¼ sec. 6, T. 6 N., R. 4 W. (Hire Township), where the section is as follows:

Section of lower Pottsville rocks exposed in SW. ¼ sec. 6, Hire Township (T. 6 N., R. 4 W.)

	Thickness	
	Ft.	*In.*
Till, glacial	3	6
Sandstone	..	4
Shale, gray above and dark in lower part	19	..
Coal, shaly, about	..	4
Sandstone, grading laterally into sandy shale	..	6
Shale, gray, sandy	4	..
Limestone, concretionary, black, pyritic	..	3
Shale, black, with concretions	..	11
Sandstone, yellowish-brown	2	..

The elevation of the base of the exposure described above is about 630 feet. The concretions in the limestone member of the section contained the fossils *Productus sp.*, and *Spirifer cameratus,* and considerable of the mineral sphalerite. The base of the section is very near the base of the Pottsville as is shown by the fact that only a few yards down the stream from this outcrop the St. Louis limestone is exposed in the bed of the stream at an altitude of 628 feet above mean sea level. The lowest member of the Pottsville in this region is in some places a sandstone and in others shale, which is usually of a peculiar greenish or bluish color.

Farther west, in the NW. ¼ sec. 13, Fountain Green Township (T. 6 N., R. 5 W.), outcropping strata show the following succession:

Section of Pottsville strata exposed in sec. 13, Fountain Green Township (T. 6 N., R. 5 W.)

	Thickness	
	Ft.	*In.*
Soil and glacial till	5	..
Shale, sandy, and shaly yellow and white sandstone	2	..
Shale, soft, black, with many iron-lime concretions up to 10 in. in diameter	1	6
Shale, soft, black, without concretions	1	..
Shale, sandy, white to yellow	8	..
Sandstone, white, thin bedded	2	..

The altitude of the base of the above section is 626 feet. Strata corresponding to some part of the section last described are exposed along the wagon road between sections 7 and 12, T. 6 N., Rs. 4 and 5 W. above an altitude of 634 feet. Farther north along a branch of La Harpe creek in sec. 34, La Harpe Township (T. 7 N., R. 5 W.) the following sequence of

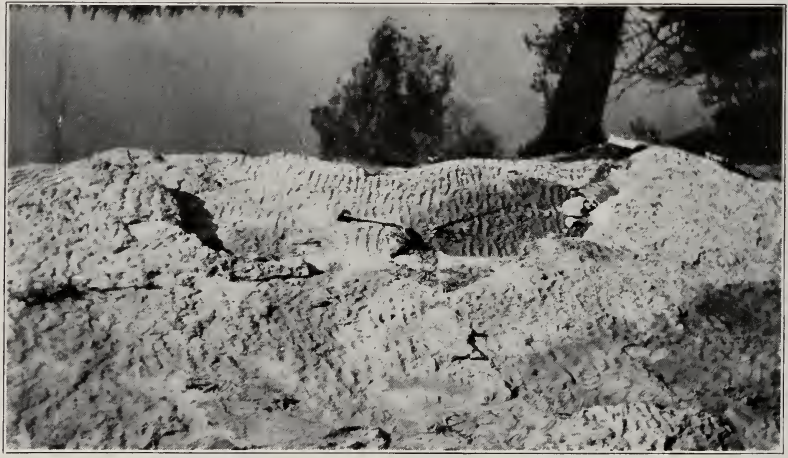

FIG. 6. Strongly ripple-marked Pottsville sandstone along La Harpe Creek, NW. ¼ sec. 35, T. 7 N., R. 5 W. (La Harpe Twp.).

Pottsville strata is exposed; the altitude of the base of the section being about 616 feet.

Section of Pottsville strata exposed in NW. ¼ sec. 34, La Harpe Township (T. 7 N., R. 5 W.)

	Thickness *Feet*
Sandstone, thin bedded	6
Shale, yellow	1
Shale, blue	1
Limestone, nodular, ferruginous	2
Shale, gray	4

Thin bedded, strongly ripple-marked layers of sandstone outcrop about 2 miles east of the last exposure, in the NW. ¼ sec. 35, of the same township. A photograph of the ripple-marked surface of this sandstone is shown in Figure 6, and a section of the strata is given below.

Section of Pottsville rocks exposed in NW. ¼ sec. 35, La Harpe Township (T. 7 N., R. 5 W.)

	Thickness	
	Ft.	*In.*
Sandstone, white, thin bedded, ripple marked	1	..
Shale, soft, dark gray, with large calcareous concretions	2	4
Sandstone, white, in thin layers, strongly ripple-marked	1	2

The Rock Island (No. 1) coal, which is exposed a few feet above the base of the Pottsville farther east in the La Harpe quadrangle does not seem to be present in this part of the area.

Near the northeast corner of the La Harpe quadrangle the lower Pottsville rocks contain a considerable thickness of sandstone. Along a branch of Ellison Creek in the NW. ¼ sec. 30, Ellison township (T. 9 N., R. 3 W.), an 18-foot ledge of sandstone in layers, which are thin below and thick in the upper part, is exposed above an elevation of 705 feet. An outcrop in the banks of Ellison Creek, one and one-half miles east of the last exposure shows a maximum thickness of 25 feet of sandstone in thick and thin layers, which doubtless corresponds to that at the locality last mentioned. This sandstone underlies 6 feet of sandy shale and belongs near the middle part of the Pottsville, as that formation is developed in this region. The altitude of the base of the sandstone is about 687 feet.

In the Good Hope quadrangle a driller's log of a boring in the SW. ¼ sec. 9, Walnut Grove Township (T. 7 N., R. 2 W.) indicates a thickness of 80 feet of Pottsville strata.

Drillers' log of a well in sec. 9, Walnut Grove Township (T. 7 N., R. 2 W.)

	Thickness		Depth	
	Ft.	*In.*	*Ft.*	*In.*
Pleistocene				
Soil	10	..	10	..
Sand	2	6	12	6
Carbondale				
Shale, gray	4	..	16	6
Shale, black, with concretions	3	6	20	..
Shale, gray	18	3	38	3
Coal (No. 2); Elevation 634 ft	2	..	40	3
Underclay, white	6	3	46	6
Pottsville				
Shale, hard	12	..	58	6
Rock (?)	4	6	63	..
Shale, hard	16	..	79	..
Horizon of No. 1 coal				
Underclay	5	..	84	..
Shale, hard	14	..	98	..
Shale, gray	16	6	114	6
Shale and rock	4	6	119	..
Underclay	2	6	121	6
Hard rock	3	3	124	9
Underclay	1	6	126	3
Very hard rock (probably Mississippian)	8	6	134	9

The middle portion of the Pottsville rocks is well exposed in Swan and Greenbush townships, and the best outcrops of lower Pottsville strata are near the northeast corner of the area. Along the banks of Cedar Creek, in the NE. ¼ sec. 20, Berwick Township (T. 9 N., R. 1 W.), the strata described below are exposed:

Section of Pottsville strata exposed along the Cedar Creek in sec. 20, Berwick Township (T. 9 N., R. 1 W.)

	Thickness	
	Ft.	*In.*
Coal blossom	..	6
Shale, gray	1	..
Sandstone, in a single layer, with numerous rootlets of *Stigmaria*	..	8
Sandstone, thin-bedded	..	6
Shale, gray, sandy	4	..
Coal	..	9
Shale, black	..	1
Shale, gray, fine grained	..	10

In Fulton County, the *Stigmaria* sandstone horizon occurs a short distance below the Rock Island (No. 1) coal which appears to be represented by the uppermost member of the above section. The elevation of the top of the section described above is about 635 feet. Half a mile farther down this creek in the NW. ¼ sec. 21, a ledge of gray to yellowish-brown, rather coarse, cross-bedded sandstone, in places massive and others thin-bedded, borders the north and east sides of the stream to a height of 15 to 20 feet for a distance of several rods, as shown in figure 7.

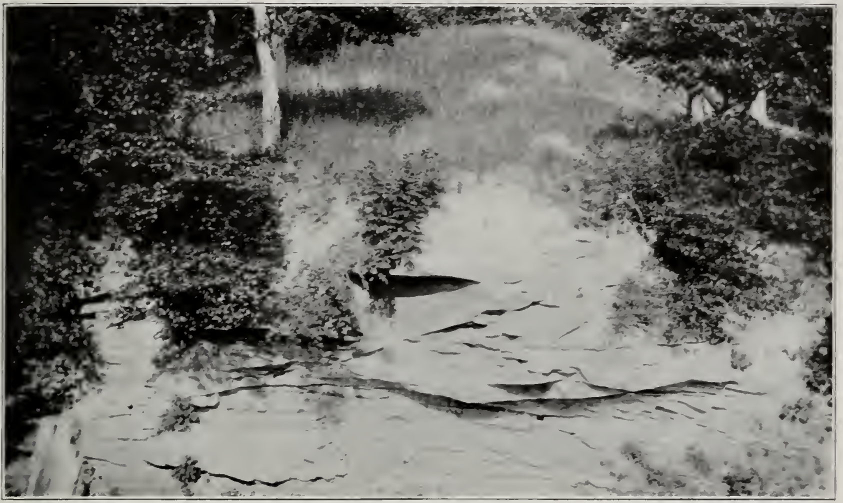

FIG. 7. Exposure of Pottsville sandstone along Cedar Creek in NW. ¼ sec. 21, T. 9 N., R. 1 W. (Berwick Twp.).

At a locality half a mile south of the outcrop last mentioned, a thickness of 25 feet of this sandstone has been quarried for rough foundation stone, above an elevation of 615 feet.

In the SW. ¼ sec. 33, T. 10 N., R. 3 W. (Tompkins), in Warren County, fragments of the hard, dark limestone that overlies the Rock Island (No. 1) coal were thrown out on the dump of an old pit from which the Rock Island coal was formerly mined and furnished the species of fossils listed below:

Fossils from fragments of limestone cap rock above the Rock Island No. 1 coal in sec. 33, T. 10 N., R. 3 W. (Tompkins) Warren County

Chonetes mesolobus
Chonetes verneuiliana
Productus cora
Productus costatus
Marginifera muricata
Marginifera cf. splendens
Spirifer cameratus
Composita argentea
cf. Nucula parva
cf. Deltopecten neglectus
cf. Macrocheilus fusiformis

In the NE. ¼ sec. 9, T. 9 N., R. 2 W. (Roseville), the dark limestone overlying the Rock Island (No. 1) coal furnished the fossils listed below:

Lophophyllum profundum
Fenestella sp.
Orbiculoidea missouriensis
Derbya crassa
Chonetes mesolobus
Marginifera muricata
Marginifera cf. splendens
Pugnax rockymontana
Ambocoelia planoconvexa
Spirifer cameratus
Spiriferina kentuckyensis
Reticularia perplexa
Composita argentea
Euphemus carbonarius
Bellerophon percarinatus
Petallostium montfortianum
Trepospira illinoisensis
Macrocheilus primigenius
Edmondia cf. aspenwallensis
Edmondia ovata
Schizodus curtus
Cardiomorpha missouriensis
Aviculopecten occidentalis
Lima retifera
Pleurophorus cf. radiata
Streblopteria tenuilineata
Orthoceras sp.
Griffithides sp.

The Rock Island (No. 1) coal is absent in several places in the Good Hope quadrangle, as in the SE. ¼ sec. 17, T. 8 N., R. 2 W. (Swan), where the limestone cap rock of this coal, and several feet of overlying strata are exposed in the banks of Swan Creek, as follows:

Section of strata along Swan Creek in sec. 17, T. 8 N., R. 2 W. (Swan)

	Thickness	
	Ft.	*In.*
Loess, yellow	4	..
Sand and gravel	1	3
Shale, soft	3	..
Sandstone, shaly, soft, thin-bedded	4	..
Shale, sandy, ferruginous, with many limonite concretions, and two or three thin lenses of coal	2	6
Limestone, hard, dark, fine grained fossiliferous, with a band of cone-in-cone at the top	..	8
Shale, gray, soft	2	2
Shale, black, to base of exposure	1	..

The limestone member of the above section is the cap rock of the Rock Island coal and furnished the fossils *Derbya crassa, Orthonema conica, Aclisina robusta,* and *Orthoceras rushense.* Strata belonging to a somewhat higher horizon of the Pottsville are exposed in the banks of Swan Creek in the NE. ¼ sec. 16, T. 8 N., R. 1 W. (Greenbush), where the following section was made:

Section of strata along Swan Creek, NE. ¼ sec. 16, T. 8 N., R. 1 W. (Greenbush)

	Thickness	
	Ft.	*In.*
Shale, gray, soft	1	6
Coal, shaly (elevation, 620 feet)	1	..
Shale, gray, soft	3	..
Shale, nearly white, clayey	2	6
Shale, black, hard	5	11

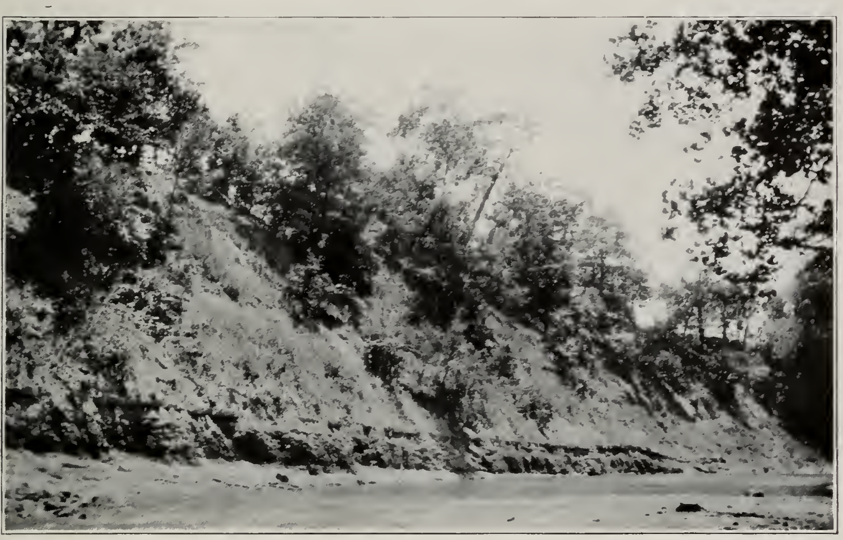

FIG. 8. Gently inclined Pottsville strata, on Swan Creek, NE. ¼ sec. 16, T. 8 N., R. 1 W. (Greenbush Twp.).

In some places in this vicinity a band of ferruginous and carbonaceous sandstone about a foot thick is present immediately above the basal black shale member of the foregoing section. Such is the case a few rods farther down this creek, where sandstone is exposed below the black shale horizon mentioned above, as shown in Figure 8.

Near the southeast corner of sec. 8 of the same township, 4 feet of gray shale is exposed overlying a layer of sandstone 18 inches thick above a few inches of sandy shale. These strata outcrop again about 40 rods farther down the creek, and in the opposite bank.

Somewhat higher layers of the Pottsville are exposed farther west in the banks, and along the tributaries, of Swan Creek in Swan Township (T. 8 N., R. 2 W.). Near the middle of the north side of the NE. ¼ NW. ¼ sec. 15 of this township the following succession of strata is exposed:

Section of Pottsville strata exposed in NE. ¼ NW. ¼ sec. 15, T. 8 N., R. 2 W. (Swan)

	Thickness	
	Ft.	*In.*
Shale, gray to bluish	20	..
Coal blossom	..	1-2
Shale	1	..
Sandstone, to level of water	1	..

The elevation of the top of this section is about 677 feet, which is about 7 feet lower than the base of the Murphysboro (No. 2) coal about one-fourth mile northeast of this locality.

In the north bank of Swan Creek, in sec. 10 of Swan Township, the following strata which belong in the upper part of the Pottsville are exposed:

Section of Pottsville strata exposed in sec. 10, T. 8 N., R. 2 W. (Swan)

	Thickness *Feet*
Shale, bluish-gray	10
Sandstone, gray, soft	2
Shale, sandy, soft	4
Sandstone, yellowish-gray, thin-bedded	4
Shale, gray	1

Where they are present the most easily recognized stratigraphic horizons in the Pottsville of this region are (1) the Rock Island (No. 1) coal, and its hard, dark limestone cap rock; (2) the stoneware clay bed; and (3) the concretionary limestone at the top of the formation.

The Rock Island coal commonly occurs 30 to 50 feet above the base of the Pottsville, and 30 to 40 feet below the Murphysboro (No. 2) bed. The stoneware clay horizon is usually 15 to 25 feet below the Murphysboro coal and 10 to 20 feet above the Rock Island coal bed. The thin concretionary limestone, which in the Avon quadrangle on the east, and in the Colchester and Macomb quadrangles to the south, commonly occurs 5 to 10 feet below the Murphysboro coal, is exposed in only a few places in the La Harpe and Good Hope quadrangles.

CARBONDALE FORMATION

All of the rocks in the La Harpe and Good Hope quadrangles lying below the unconsolidated Pleistocene deposits, and above the Pottsville strata are included in the Carbondale formation. These rocks suffered extreme erosion during the long post-Pennsylvanian-pre-Pleistocene land interval, and only the lower part of the formation has been preserved in these quadrangles.

The greatest known thickness remaining in the region is 65 feet, but in most places where it is found the thickness is less than 35 feet.

The Carbondale formation consists in large part of shales but contains one rather persistent coal, the Murphysboro (No. 2) bed, and in places some sandstone or sandy shale. The formation rests conformably upon the Pottsville, and is unconformably overlain by unconsolidated deposits of Pleistocene age.

The formation is present beneath the glacial drift over the greater part of the east half of the La Harpe quadrangle, except at the north end, and over almost all of the Good Hope area except a few square miles in the northeast part and a belt 3 to 4 miles wide along the south end. The best outcrops occur along the South Branch of Crooked Creek; in the banks of La Harpe and Baptist creeks in the south central part of the La Harpe quadrangle; north of Roseville; and north and northeast of the village of Swan Creek, along Big Nigger Creek and Swan Creek, in the Good Hope area.

Murphysboro (No. 2) coal and associated strata.—The Murphysboro coal was called "coal No. 2" by Worthen in the earlier series of reports of the Geological Survey of Illinois. It is underlain by a thickness of 2 to 5 feet of gray underclay which, in the Colchester and Macomb quadrangles, is considered the basal member of the Carbondale formation. This coal is very persistent throughout all of this region, wherever the formation has escaped erosion. Its thickness ranges from 2 to 2½ feet and is so uniform that the coal is often referred to as the 30-inch bed. This coal is overlain by rather soft, light bluish-gray shale which becomes slightly sandy in the upper part. The thickness is commonly 8 to 12 feet, but in places it reaches 25 feet or more. In most places this light shale is succeeded by a bed of hard, black, laminated shale, 2 to 6 feet thick, which near the top contains a band of dark, septarian, fossiliferous limestone concretions, 8 to 24 inches in diameter.

The succession of strata described above is well exposed in the SW. ¼ NW. ¼ sec. 22, Greenbush Township (T. 8 N., R. 1 W.):

Section of rocks exposed in sec. 22, T. 8 N., R. 1 W. (Greenbush)

	Thickness	
	Ft.	*In.*
Clay pebbly, yellow	3	..
Shale, gray, with iron concretions	4	..
Band of dark, fossiliferous, septarian limestone	..	6-8
Shale, gray to dark	3	..
Shale, black, laminated, with iron-stone concretions	1	6
Shale, soft, gray	9	6
Coal (Murphysboro or No. 2 bed)	2	3
Underclay, gray	1	..

The elevation of the coal at this place is 625 feet above sea level. A sequence of strata similar to that described above, was encountered in drilling a well in the SW. ¼ sec. 30, Roseville Township (T. 9 N., R. 2 W.), as shown in the following log:

Log of boring in the SW. ¼ sec. 30, T. 9 N., R. 2 W. (Roseville)

	Thickness *Feet*	Depth *Feet*
Soil, black	3	3
Clay, bluish, pebbly	20	23
Shale, black, laminated	7	30
Shale, soft, light colored	8	38
Coal (Murphysboro or No. 2 bed)	2½	40½
Underclay, gray	5½	46

The concretionary and septarian zone at the top of the black shale outcrops in a few places in the SE. ¼ sec. 21, Blandinsville Township (T. 7 N., R. 4 W.), as described below:

Section of strata exposed in sec. 21, Blandinsville Township (T. 7 N., R. 4 W.)

	Thickness *Ft.*	*In.*
Shale and calcareous concretions	2	..
Shale, soft, gray, with a few small ironstone concretions	5	..
Discontinuous band of septarian limestone	..	4
Shale, gray	..	6
Shale, black, with a band of fossiliferous, hard, septarian concretions, 8 to 24 inches in diameter near the top	4	..

The lowest member of the above section corresponds with the upper part of the black, laminated shale described from sec. 30, Roseville Township (T. 9 N., R. 2 W.). The septarian limestone at this place, and the corresponding limestone exposed in sec. 22, in Greenbush Township (T. 8 N., R. 1 W.), and in the NW. ¼ sec. 9, Swan Township (T. 8 N., R. 2 W.), and in the SW. ¼ sec. 9, Walnut Grove Township (T. 7 N., R. 2 W.) furnished the species of fossils listed below:

Fossils from the septarian limestone above the Murphysboro (No. 2) coal

Lophophyllum profundum
Derbya crassa
Chonetes mesolobus
Chonetes verneuilianus
Productus cora
Productus nebraskensis
Marginifera muricata
Pugnax uta
Spirifer cameratus
Ambocoelia planiconvexa
Reticularia perplexa
Composita argentea

Fossils from the Septarian limestone above the Murphysboro (No. 2) coal—Continued.

Bellerophon percarinatus
Euphemus carbonarius
Bucanopsis meekana
Phanerotrema grayvillensis
Trematospira sphaerulata
Platyceras sp.
Cf. Cyclora minuta
Aclisina robusta
Macrocheilus primigenius
Sphaerodoma cf. texana
Nucula parva
Nucula ventricosa
Leda bellastriata
Aviculopecten occidentalis
Aviculopecten rectilaterarius
Deltopecten neglectus
Allorisma terminale
Edmondia sp.
Orthoceras rushense

A bed of bluish-gray shale, 25 to 30 feet thick, in places overlies the black shale and septarian limestone. Outcrops of this shale occur along Swan Creek and its branches in the SE. ¼ sec. 17, Swan Township (T. 8 N., R. 2 W.), above an elevation of 728 feet. It is also well exposed along the wagon road, and in the banks of Big Nigger Creek, 2 miles north of the village of Swan Creek.

In this region wherever thicknesses exceeding 15 or 20 feet of bluish-gray shale are exposed above the Murphysboro coal, without any black, laminated shale appearing in the section, it is probable that an erosional uncomformity is present within the shale, and that the black shale and septarian limestone horizon were cut out during that erosion interval.

The Vergennes sandstone member which, in places in the Avon quadrangle farther east and in the Colchester and Macomb quadrangles to the south, occurs from 10 to 30 feet above the Murphysboro coal, is not known to be present in the La Harpe and Good Hope quadrangles.

The No. 3 coal described by Worthen as occurring from 30 to 50 feet above the Murphysboro (No. 2) bed in Fulton and Schuyler counties was not formed in this region.

QUATERNARY SYSTEM

The Quaternary system, which includes all of the surficial deposits in this area, has a maximum known thickness of 200 feet, though the common range of thickness is from a few to 40 feet. The thickest drift occurs along an east-west belt across the central parts of the quadrangles where the upland surface is nearly level. The differences in the thickness of the Quaternary deposits is due chiefly to the inequalities of the surface upon which the Pleistocene deposits were laid down. Before the glaciers moved over the region the surface of the bed rock was eroded by streams so as to present valley and upland features similar to those of the present, but not corresponding in most cases to the present valleys and uplands in position or slope. Several preglacial valleys existed where now the level upland surface of the drift plain gives no indications of their presence. Figure 9 is a map showing the preglacial topography as closely as it can be determined with the information at hand. The areas of unusually thick drift occur where such preglacial valleys have been filled, and now lie beneath the level uplands. The unconsolidated deposits consist of glacial drift or till; interglacial peat, soils and sands; loess; some alluvium of Pleistocene age; and alluvial sediments and loess-like clay that were deposited during Recent time, but which can not always be distinguished from similar material deposited during late Pleistocene.

PLEISTOCENE SERIES

DIFFERENTIATION OF THE DEPOSITS

In the Quaternary deposits of this region there are thought to be represented five of the subdivisions of the Pleistocene series. The oldest of these appears to be the Kansan glacial drift, at the top of which is an old soil and forest horizon developed during the Yarmouth interglacial age. Above this is the upper or Illinoian drift which covers almost the entire region. In several places the Sangamon soil, which was originally developed over the greater part of the level surface of the Illinoian drift, has been preserved. Above the Illinoian till, or above the Sangamon soil wherever it is present, is a mantle of loess which has been spread over almost the entire surface of the quadrangles. The greater part of this loess is probably of late Iowan or early Peorian age.

Only the Illinoian drift and the loess are sufficiently widely exposed at the surface in this area that they can be shown on the map. The other Pleistocene formations are known only from outcrops of small size, and from records of wells and test borings.

KANSAN (?) DRIFT

In a few places in the Good Hope and La Harpe quadrangles what appear to be two beds of glacial drift are exposed, separated by a zone of black clay or soil containing much peat and wood fragments. A few water wells have also penetrated a similar succession of till and old soil.

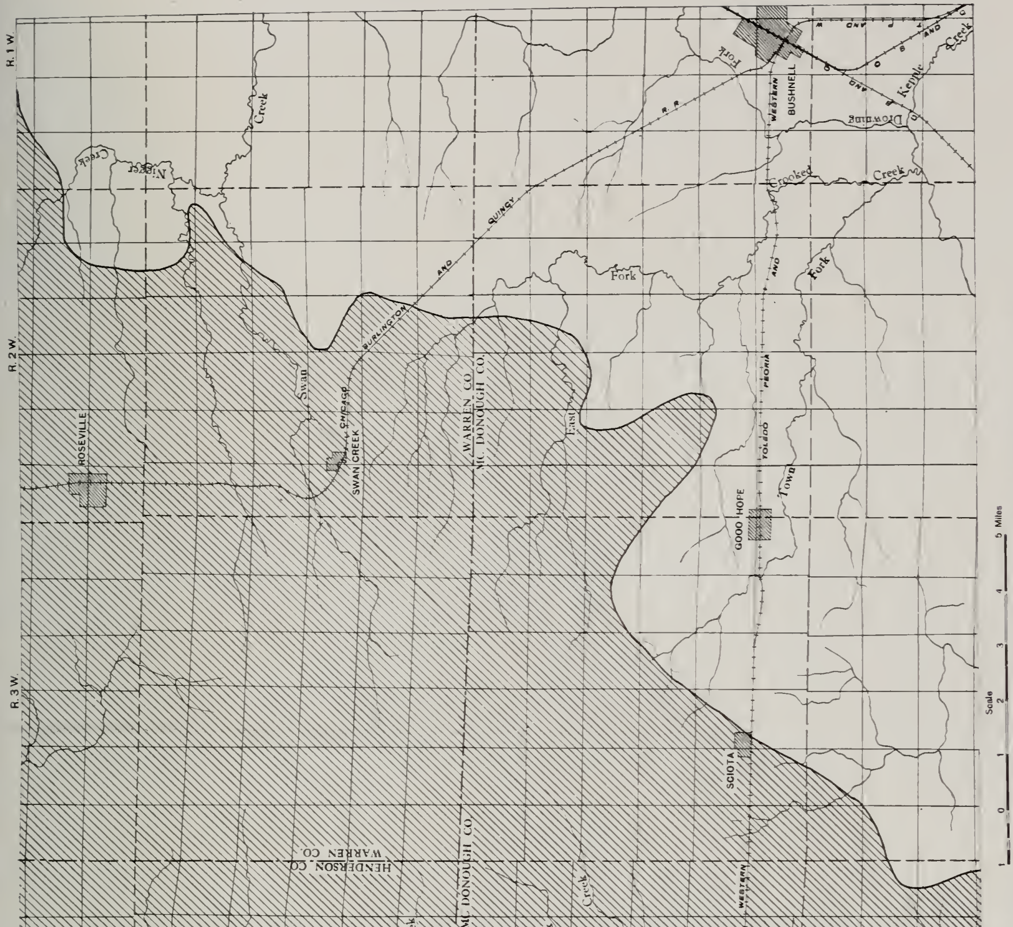

FIG. 9. Sketch map of Good Hope and La Harpe quadrangles, showing generalized pre-glacial topography. The shaded area is pre-glacial upland, and the unshaded area pre-glacial lowland.

One of the best exposures of such beds is in the SW. ¼ sec. 24, Ellison Township (T. 9 N., R. 3 W.), where the following section was made:

Section of Pleistocene strata exposed in sec. 24, T. 9 N., R. 3 W. (Ellison)

	Thickness Ft.	In.
Loess	1	..
Till, pebbly, yellow (Illinoian)	8	..
Sand, white, clayey	2	..
Clay, brown, with some sand and pebbles	..	6
Till, pebbly, black, with much vegetable matter (Yarmouth and Kansan?)	3	4

A somewhat similar section of Pleistocene strata outcrops in the NW. ¼ sec. 7, Walnut Grove Township (T. 7 N., R. 2 W.), as shown below:

Section of Pleistocene strata outcropping in sec. 7, T. 7 N., R. 2 W. (Walnut Grove)

	Thickness Ft.	In.
Loess, yellow	1	6
Till, yellow, with pebbles (Illinoian)	3	..
Clay, or silt, yellow, with black bands of organic matter (Yarmouth?)	1	6
Sand, brown to yellow	2	6
Gravel, coarse, mostly chert	1	..
Clay, brown, laminated	..	4
Till, gray to brownish-gray (Kansan?)	4	..

Another exposure in the SW. ¼, sec. 31, of the same township, also appears to indicate a till older than the Illinoian. A section of the outcrop at this place is as follows:

Section of the Pleistocene exposed in sec. 31, T. 7 N., R. 2 W. (Walnut Grove)

	Thickness Feet
Soil, dark	2
Loess, yellow	7
Till, pebbly, yellow (Illinoian)	9
Till, pebbly, and sandy, with black soil-like material (Kansan?)	13

Iowa has two drift sheets older than the Illinoian. The older one, the Nebraskan, is in most places concealed by later deposits, but is known from outcrops along streams, exposures in railroad cuts, and from well borings at a number of widely separated localities. The next younger till is the Kansan which is intermediate in age between the Nebraskan and the Illinoian. This drift is widespread west of Mississippi River, covering the larger part of Iowa and northern Missouri. Over a belt a few miles wide in southeastern Iowa, adjacent to Mississippi River, the Kansan drift is overlain by Illinoian till, and the Yarmouth soil is present between them. The exposures of the till below the Illinoian in the Good Hope and La Harpe quadrangles were so small that a satisfactory comparison of this drift with the several tills in Iowa could not be made. However, since the Kansan drift is known to immediately underlie the Illinoian till in southeastern Iowa, only a few miles west of this area, and probably also in the Edgington and Milan quadrangles in Rock Island County, only a few miles farther north, the lower drift in the Good Hope and La Harpe area is thought to represent the Kansan.

YARMOUTH (?) SOIL

In several places in the quadrangles an old soil, peat, or forest horizon underlies the Illinoian till. This soil was formed during one of the interglacial stages that preceded the Illinoian glaciation, probably during the Yarmouth, since the drift that underlies the Illinoian in this region is probably of Kansan age. Charles Selfridge, of Good Hope, who has drilled many wells in that region, says that a bed of blue clay or till usually underlies the yellow loess clay; and below the blue clay is, commonly, a layer of wood fragments and plant debris (the Yarmouth soil horizon). In some places this soil and vegetal zone rests directly on Pennsylvanian shale, and in other places there are a few feet of blue to yellow, pebbly clay (Kansan till) between the soil zone and the shale. In a well drilled near the southeast corner of sec. 9, Sciota Township (T. 7 N., R. 3 E.), the soil and peat zone beneath the Illinoian till was reported at a depth of 120 feet, but it is commonly much nearer the surface.

An exposure of such an old pre-Illinoian peat and forest zone in the NW. ¼, sec. 8, Walnut Grove Township (T. 7 N., R. 2 W.), furnished the following section:

Section of Pleistocene strata in sec. 8, T. 7 N., R. 2 W.
(Walnut Grove)

	Thickness	
	Ft.	*In*
Clay, yellow (loess)	6	..
Clay, brown, with few or no pebbles	4	..
Till, brown to yellow, pebbly	2	..
Gravel, coarse	2	..
Sand, and fine gravel, cross-bedded	3	6
Gravel, coarse bowlders up to 8 inches in diameter	1	6
Sand, brown	1	..
Clay, dark, containing rotten wood and much peaty material apparently derived from decomposed drift-wood	2	..

Sediments that appear to represent alluvial deposits of Yarmouth time are exposed in the bank of Swan Creek for a distance of several rods in the NW. ¼, sec. 17, Greenbush Township (T. 8 N., R. 1 W.), as shown below and in figure 10.

Section of Pleistocene strata exposed in sec. 17, T. 8 N., R. 1 W.
(Greenbush)

	Thickness	
	Ft.	*In.*
Loess	1	..
Till, pebbly (Illinoian)	2	..
Sand, interbedded with clay, gray to yellow	10	..

Section of Pleistocene strata exposed in sec. 17, T. 8 N., R. 1 W. (Greenbush)—Continued.

	Thickness Ft.	Thickness In.
Clay, gray, sandy, laminated	2	..
Sand, black, coarse	..	6
Soil or peat, brown and black, with many twigs and wood fragments (Yarmouth)	7	2
Clay or silt, bluish-gray, fine, with many small gastropod shells	3	..

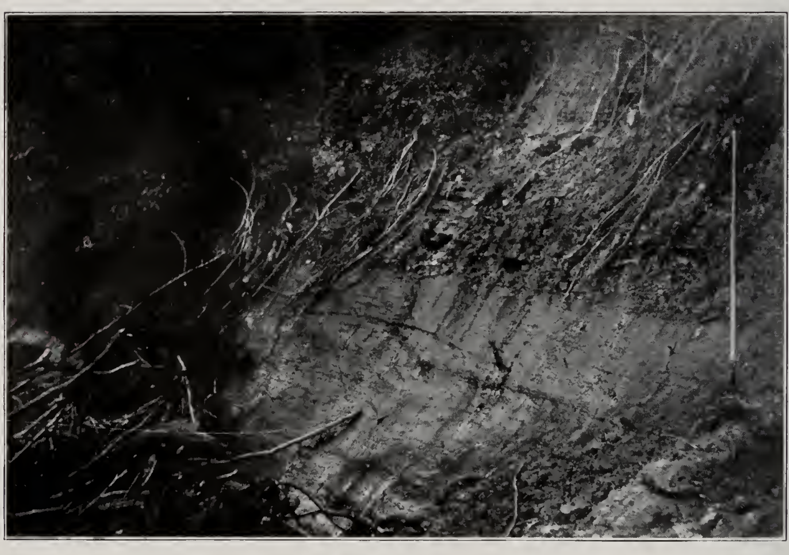

FIG. 10. Yarmouth (?) soil and peat exposed in NW. ¼ sec. 17, T. 8 N., R. 1 W. (Greenbush Twp.).

ILLINOIAN DRIFT

The Illinoian till underlies the thin mantle of loess over the surface of the entire upland area, and over the greater part of the slopes. The upper surface of the Illinoian till, beneath the loess, presents a topography similar to that of the present surface. The lower surface of the drift is more uneven, conforming to the irregular topography developed by erosion of the pre-Illinoian surface. The thickness of this drift varies greatly from place to place.

Adjacent to the larger streams the larger part of the till has been removed by recent erosion, but where the Pleistocene deposits are very thick, the thickness of the Illinoian till is commonly the greatest. In many of the well records obtained it is impossible to distinguish the Illinoian till definitely from some of the associated deposits of waterlaid sand and clay; hence the exact thickness of till cannot always be determined. However, where the Pleistocene deposits are thin, they commonly consist largely of Illinoian till, and where they are thick the larger part of the materials is

Illinoian, except in a few localities where the associated sand and gravel deposits are unusually well developed.

Within the till, pockets and lenses of sand often occur. Beds of sand and gravel a few feet thick and often of considerable areal extent are not infrequently present in the lower part of the till or immediately above or below the main drift deposit.

The Illinoian till consists for the most part of sandy clay containing pebbles scattered more or less irregularly throughout. Most of the pebbles are small, ranging from a quarter of an inch to one inch in diameter, but larger ones are not infrequent, and occasional boulders of crystalline rock up to 3 or 4 feet in diameter are found in places. The pebbles and boulders are commonly angular and striated on one or more sides. The larger boulders are in most cases of igneous or metamorphic rock foreign to the region, but

TABLE 1.— *Relative number of different kinds of pebbles in gravel associated with Illinoian drift; in the NW. ¼ sec. 15, T. 8 N., R. 1 W. (Greenbush)*

Kind of rock	Average size about ½ inch in diameter	Average size about 1 inch in diameter	Average size about 2 inches in diameter
	Number	*Number*	*Number*
Chert (local)	141	104	33
Quartz (mostly vein)	92	28	2
Sandstone	26	4	4
Iron concretion (from sandstone)	12	4	..
Quartzite	12	2	..
Metamorphic	5	..	1
Conglomerate (quartzitic)	13	1	..
Schist	2	..	..
Diabase	1	2	..
Granite	..	1	1
Oolite, silicified	2	2	..
Shale, hard	..	1	..
Geode	..	..	1
Total	306	149	42
Summary			
Local material	181	112	38
Foreign material	125	37	4
Origin			
Sedimentary	181	115	39
Quartz, mostly vein, origin uncertain	92	28	1
Metamorphic	32	3	1
Igneous	1	3	1

the larger number of the pebbles in the gravel associated with the Illinoian drift are of local derivation as shown by the count of the various kinds in three collections made in the NW. ¼, sec. 15, Greenbush Township (T. 8 N., R. 1 W.). The results are shown in Table 1.

From the predominance of pebbles of local origin in the gravel associated with the Illinoian till, it is apparent that the source of much the larger per cent of the Illinoian drift pebbles in this region was doubtless residual materials of sedimentary rock at no great distance away; and the main body of the drift was here probably derived for the most part from local beds of shale and sandstone which were deeply weathered when the ice sheet moved over them.

The color of the upper portion of the till is commonly yellow, or yellowish-brown, but changes to some shade of blue at considerable depths where the drift has not been affected by the agents of weathering.

The general character, thickness, and relations of the Illinoian till and associated sand beds are indicated in the preceding sections describing the Kansan till and Yarmouth? soil, and in the following sections showing the Sangamon soil and the loess.

In several places in the Good Hope quadrangle, and in a few localities in the eastern part of the La Harpe area, low, elliptical or oval shaped, more or less irregular ridges rise 10 to 20 feet above the surrounding upland. These ridges are on the divides and uplands and usually trend in a general east-west direction parallel to the interstream divides. One of the most conspicuous belts of such hills crosses the middle part of the Good Hope quadrangle. They are composed of till covered with a veneer of loess, and somewhat resemble morainal ridges, but it is probable that they represent minor irregularities of deposition of glacial drift on the upland surfaces.

SANGAMON SOIL

The Sangamon soil zone was developed on the Illinoian till during the interglacial stage that followed the withdrawal of the Illinoian ice sheet. This stage was called the Sangamon because of the widespread development of a soil and forest bed at the top of the Illinoian till in the northern part of Sangamon County. The Sangamon soil is exposed in only a few places in the Good Hope and La Harpe quadrangles, but it has been penetrated in several water wells in the area, and it was doubtless originally developed on the flatter portions of the surface of the Illinoian till over all of this region. Since the valleys of Sangamon time were in practically the same places as those of today, though smaller in size, the old soil does not often outcrop along the slopes where the top of the Illinoian till comes to the surface.

The Sangamon soil consists of dark, carbonaceous clay, containing a large amount of organic matter, including peat, branches of trees, and fragments of wood. It is commonly encountered at depths of 10 to 20 feet, and in many places is directly overlain by loess, but in others it is separated from the loess by a bed of sand.

The following detailed sections of outcrops, and records of wells in the region will show the relations of the Sangamon soil to the associated beds of surficial materials.

A section of Pleistocene strata exposed in the south bank of Crooked Creek in sec. 9, Walnut Grove Township (T. 7 N., R. 2 E.), is as follows:

Section of Pleistocene strata exposed in sec. 9, T. 7 N., R. 2 E.

	Thickness	
	Ft.	*In.*
Clay, yellow, and sand	10	..
Sand and gravel	3	..
Clay, gray, with matted vegetable matter, and branches of trees 3 inches in diameter and more than 3 feet long, and small gastropod shells	..	4
Soil, black, sandy, with much peaty matter	4	..
Clay, blue, sandy and pebbly, with some peat	2	..

In digging a well in 1914 in fractional section 3, Terre Haute Township (T. 8 N., R. 5 W.), the jaws and teeth of a fossil elephant, *Elephas columbi,* were found in the black Sangamon soil bed about 24 feet below the surface. The log of this well is given below:

Log of well in sec. 3, T. 8 N., R. 5 W. (Terre Haute)

	Thickness		Depth	
	Ft.	*In.*	*Ft.*	*In.*
Soil, black	2	..	2	..
Sand, cemented with iron	8	..	10	..
Sand, yellow	..	1	10	1
Quicksand, white	8	..	18	1
Wood fragments, brown, like peat	2	..	20	1
Soil, black, full of plant debris resembling leaves of prairie grass	4	..	24	1

The elephant remains were found in the basal member of the above section by John Shick of Stronghurst, in whose possession the teeth may be seen at the present time. A water well on the same farm was said to have been dug to a depth of 60 feet, and bored 50 feet deeper in blue pebbly clay without reaching the bottom of the till.

The log of a well in the NE. ¼, sec. 22, Hire Township (T. 6 N., R. 4 W.), is as follows:

Log of well in sec. 22, T. 6 N., R. 4 W. (Hire)

	Thickness	Depth
	Feet	*Feet*
Soil, black	2	2
Clay, yellow	9	11
Peat, brown to black, full of leaves like prairie grass	3	14
Clay, blue, with some sand	6	20

LOESS

Except adjacent to the streams where it has been removed by erosion the loess forms a mantle over the Illinoian drift and Sangamon soil in all of this region. On the uplands and the upper parts of the valley slopes it ranges from 5 to 10 feet thick and conceals the underlying till. On the lower parts of the slopes near the stream levels the thickness is reduced to a thin veneer. In most places where the loess and the underlying till is exposed, there is no well developed soil zone or band of concentrated pebbles present at the contact, although commonly transition from the till to the loess is rather abrupt. The Sangamon soil, like the black soils of the present surface, was doubtless developed only over the more poorly drained areas at a distance from the stream channels which would explain the usual absence of the soil where the contact of the loess and till is exposed on the slopes.

The loess is composed of uniformly fine grained, calcareous, unconsolidated, and unstratified or very imperfectly stratified, dust-like material. On the slopes it is commonly gray to yellow, or yellowish-brown, and often contains shells of air breathing gastropods. On the level interstream areas the soil developed on the loess is dark to a depth of 3 to 4 feet, and the underlying loess is more gray in color. The loess on the slopes and that on the uplands is doubtless of similar origin. The difference it presents in the two localities is probably due in part to the greater amount of leaching that it has undergone on the slopes, and in part to the changes produced by the larger content of organic matter in the loess of the upland prairies.

The loess in this area as elsewhere in the Mississippi valley was doubtless deposited by the wind. This is shown by the following facts: (1) it does not tend to level up the inequalities of the surface but mantles the lowlands, slopes, and uplands alike; (2) it does not show such distinct stratification as is produced in the deposition of such material by water; (3) it contains shells of air breathing snails which, though very fragile, are not broken, belonging to species which now live on dry hill slopes.

The geographic relations of the thick deposits of loess to the border of the Iowan drift sheet; the stratigraphic position of the main deposit above the Sangamon soil and Illinoian till, and the older drift sheets, and below the Wisconsin till; its scant development on the surface of the Iowan and the Wisconsin drift sheets; and the presence in the deposit of shells of gastropods belonging to species that lived under climatic conditions similar to those prevailing in the region today, make it probable that conditions were unusually favorable for the accumulation of wind blown deposits of loess during late Iowan and early Peorian time.

A small amount of loess overlies Iowan and Wisconsin drift in some places in Iowa and Illinois, and covers the lower part of valley slopes that have been cut in recent time. Dust deposits somewhat resembling loess are in places now being formed by the wind. Hence it is probable that a part of the original main deposit of loess has been shifted in different places and that other dust deposits have been accumulated since Peorian time, but the total amount of such material is comparatively small.

RECENT SERIES

ALLUVIUM

In the absence of rivers of any considerable size in the La Harpe and Good Hope quadrangles, the areas of stream flood plain are not extensive. Narrow belts of alluvium are present along the larger creeks, and even near their headwaters and along portions of their tributaries. The widest areas are in the valleys of Swan and Crooked creeks, in the Good Hope quadrangle, and along Honey and La Harpe creeks, and the North and South branches of Crooked Creek in the La Harpe area. These flood plain areas are in places ¼ to ½ mile wide, but bordering the smaller streams the width for considerable distances does not average more than a few hundred feet. The deposit commonly ranges in thickness from a few to 10 or 12 feet along the larger streams, but in most places the thickness is less than the above figures. The materials consist largely of dark, sandy clay which has been derived for the most part from erosion of the till and loess.

STRUCTURE

General Statement

In a region where the rocks dip as gently as they do in western Illinois, the structure may best be represented by structure contour maps. These maps are constructed by determining at as many places as possible, the elevation above sea level of one or more definite beds which can be recognized over extensive areas and plotting these elevations, and then drawing lines through points having the same elevation above sea level. In parts of the Good Hope and La Harpe quadrangles elevations have been obtained for two such horizons, the Murphysboro coal, and the base of the Burlington limestone. The resulting structure is shown by means of contour lines on the accompanying structure maps. The coal contours are the heavy olive lines drawn at 20-foot intervals through points of equal elevation. Along a given contour line the coal is 20 feet higher or lower, as the case may be, than along the next, rising more or less uniformly from one to the other. The Burlington limestone contours are shown in red, and are drawn at 50-foot intervals through points of equal elevation. These contours are based principally upon studies of the records of deep wells which passed through this limestone. Only a few such records are available, and they are scattered over a large area so that the structure is more generalized than that indicated by the coal and only the larger irregularities of the strata are brought out.

USE OF STRUCTURE CONTOUR MAP

By subtracting the elevation of the coal or of the base of the Burlington limestone, as shown by the structure contour map, from the surface elevation at any given place, as shown by the surface contours, the approximate depth to the coal or to the base of the limestone can be obtained as desired. This method is especially valuable in case it is desired to test for coal under any particular tract of land.

At points between structure contours the altitude of the coal or key horizon is intermediate between that shown by the contours on either side. In a similar way the altitude of any other stratum above or below a key horizon may also be determined. If the stratum is below the key horizon, the vertical interval between it and the key stratum should be added to the elevation of the latter; and if the stratum the altitude of which is desired lies above the key horizon, the vertical interval between them should be subtracted from the altitude of the key horizon.

In addition to showing the depth and the altitude of any layer, structure contours also represent the main features of the rock structure, and the direction and steepness of the dips. The dip in feet per mile can be read directly from the map. It is always assumed that the dip is uniform between two adjacent contour lines. Undulations of less vertical height than the contour interval are not shown on the map.

ACCURACY OF CONTOURS

Errors in representing structure by contour lines may result from inaccurate determination of the altitudes of outcrops, shafts, and borings, from too great distances between the points at which the elevation of the key horizon is determined, and irregularity in the stratigraphic intervals. On the topographic maps of the Good Hope and La Harpe quadrangles numerous bench marks are shown, and it is possible to hand-level from points of known altitude to almost any place whose altitude is desired, with a good degree of accuracy.

Where outcrops of key horizons are few and when the wells, borings, or shafts that have penetrated the key horizons are long distances apart, the chances of error in the structure contours will be greater than where the points at which the altitude of the key horizons can be determined are closer together. Over the portions of the quadrangles underlain by the Murphysboro (No. 2) coal the outcrops and borings are fairly numerous, and the contours are reasonably accurate; but over the areas where the coal is absent and the base of the Burlington limestone was used as the key horizon, the wells and borings that penetrate this horizon are so few that the contours are considerably generalized, and may show a vertical error of several feet. Where the data are insufficient for a fair degree of accuracy the structure contours are shown as broken lines.

Another source of error in this region is the irregularity of the stratigraphic section. This can be seen from the lack of complete correspondence between the structure contours based on the Murphysboro (No. 2) coal, and on the base of the Burlington limestone. This lack of perfect parallelism between these horizons is due to the fact that in this region structural disturbances took place at times in the intervals between the deposition of the successive formations so that the strata now exposed at the surface are not necessarily parallel with the layers of the deeper lying formations. Comparing the two sets of structure contours shown on the maps it will be seen that both have the same general direction of dips—towards the east and south—but the Burlington limestone dips more steeply than the coal.

At a point near the middle of the west side of the Good Hope quadrangle the altitude of the base of the Burlington limestone is about 500 feet, while 12 miles farther east, near the middle of the east side of the same quadrangle the elevation is only 235 feet. The eastward decline of the limestone in this distance is 265 feet, or an average of about 22 feet per mile. Between the same points the eastward dip of the Murphysboro (No. 2) coal is only 87 feet, or about 7¼ feet to the mile. The southward dip of the Burlington limestone, between the middle and south parts of the La Harpe quadrangle is about 170 feet, while the coal dips only 71 feet in the same distance.

Structure of the Quadrangles

The structure of the region is comparatively simple. The rocks have a gentle dip to the east and south from a high area in the northern part of the La Harpe quadrangle. The principal structural feature is a dome near Stronghurst where the base of the Burlington limestone lies at an elevation of 600 feet, while south of La Harpe it has declined to an elevation of only 300 feet. There is a similar dip towards the eastern edge of the Good Hope quadrangle where the limestone lies at an elevation of only 250 feet. To the west it appears to dip rather steeply to an elevation of 390 feet. South of Stronghurst the limestone dips off rather uniformly to an elevation of 300 feet south of the La Harpe. South of Good Hope the southeast dip is modified by a small dome upon which the limestone rises to an elevation of about 450 feet.

The coal shows the same general direction of dip as the Burlington limestone. From west to east across the central portion of the Good Hope quadrangle the limestone dips 260 feet, while the coal dips only 80 feet in the same distance. In the southern portion of the La Harpe quadrangle likewise the limestone has a much steeper dip than the coal. This indicates a considerable thickening to the south and east of the rocks lying between these two horizons. The thickening is toward the center of the large Illinois basin which existed as an area of deposition during Mississipian and Pennsylvanian times.

The ideal key horizon on which to determine structure to be used as a guide in prospecting for oil is the upper surface of the oil sand itself. In the absence of sufficient data concerning the sand, the next best key horizon, other things being equal, is the one approaching nearest to the oil sand in depth. In the Good Hope and La Harpe quadrangles the base of the Burlington limestone probably best fulfills these conditions, and the structure shown by the contour lines drawn in this horizon should be considered first in selecting locations for drilling.

In detail, the coal contours show that the generally simple structure is modified locally by small anticlines, synclines, and terraces. West of Roseville is a small anticline where the coal rises to an elevation of 736 feet, which is 30 feet higher than its altitude to the south and east. East of Roseville is another low dome where the coal lies at about 720 feet, which is 20 feet higher than the elevation of the bed in the surrounding area. Between the two the coal dips to about 685 feet. North of Youngstown is a terrace upon which the coal lies at an elevation of 680 feet, while further east it dips into a pronounced syncline to an elevation of 620 feet. North of Blandinsville is another terrace where the coal lies at about 680 feet, dipping away rather steeply to the south. There is not sufficient data upon which to base an interpretation of the structure of the coal to the north of this terrace, but it probably rises to conform with the structure shown by the Burlington limestone. Six miles northwest of Bushnell there is a small dome in which the coal rises 20 feet higher than in the adjacent region.

Many minor irregularities are present that are too small to be indicated by structure contours. Such small undulations are especially common in Pennsylvanian strata, and are probably due to unequal settling of the clays or shales, and other sediments containing greater or less amounts of organic matter, and also to deposition upon a somewhat uneven surface. Such features are especially noticeable in coal mines where the haulage and drainage are made more difficult by relatively slight dips. Faults are not common in this region, and in none of them is the known vertical displacement more than a very few feet.

GEOLOGIC HISTORY

Paleozoic Era

The geologic history of Illinois during the Paleozoic era is recorded in a thickness of several thousand feet of strata that were mostly deposited in seas that at different times covered a part or the whole of the state. These rocks were laid down as layers of sand, clay, and more or less broken shells or of mixtures of these materials. These sediments became consolidated by cementation and pressure, into beds of sandstone, shale, and limestone. Information concerning the history of pre-Mississippian periods in this region was obtained from the records of deep wells and borings, some of which penetrated strata representing the Upper Cambrian period. In addition to the records that have been preserved within the quadrangles many facts regarding the geologic history of the area have been inferred from the results of studies of other areas in this general region, for the processes that have operated in the quadrangles also affected an extensive province surrounding them, so that most of the history of the smaller area is contained in the more ample record of the larger region. No distinct record has been preserved in this region of the events that occurred between the Pennsylvanian and the Quaternary periods, although it is known that land conditions prevailed and the dominant process in operation was the more or less interrupted progress of erosion.

During the Paleozoic era, Illinois was at successive times submerged beneath an epicontinental sea, the shores of which shifted more or less continuously, though at rates that varied in different places at the same time and at the same place at different times. With the exception of the extreme southern part, the surface of the state has been continuously above the sea subject to weathering and erosion since the end of the Paleozoic era.

CAMBRIAN PERIOD

At the opening of the Paleozoic time the surface of Illinois had been above the sea for so long that it had been reduced by erosion to a nearly level plain. The oldest rocks that have been encountered in deep wells in the State were laid down in the latter part of the Cambrian period in a sea that gradually advanced over the region from the southwest. During this submergence the streams that drained into this sea carried from the bordering lands great quantities of sand and clay which were spread out in layers over extensive areas to a thickness of several hundred feet. These sediments make up the formations included in the Upper Cambrian ("Potsdam" or Croixan) sandstone.

ORDOVICIAN PERIOD

By the end of Cambrian time the lands had been worn so low that the streams eroded very slowly and carried but little sand and mud to the epicontinental sea that covered this region. In this clear water there flourished great numbers of animals that formed shells or hard parts of lime carbonate. The shells left by successive generations of organisms accumulated in thick beds which subsequently became altered to magnesium-calcium carbonate or dolomite, and comprise the "Lower Magnesian" limestone. Limestone deposition was stopped by the withdrawal of the sea and land conditions prevailed for a long time in this region. Later the sea returned, and over the eroded surface of the limestone the sand of the St. Peter formation was deposited by the waves, and shifted and resorted by the winds that swept over the wide beaches of the St. Peter Sea, until it became thoroughly washed and very perfectly sorted. After St. Peter time conditions in this interior sea again became favorable for the growth of great numbers of animals that secrete calcareous shells and the Plattin and Kimmswick limestones were accumulated in the central and southern parts of the State and the Platteville and Galena limestones were deposited farther north, after which a withdrawal of the sea put a stop to deposition. During the next submergence which followed a long land interval, the greater portion of Illinois received deposits of mud, sand, and limy sediment which now make up the shales, sandstones, and limestones of the Maquoketa or Richmond formation. Following the deposition of these sediments, a sea withdrawal closed the Ordovician record in this region.

SILURIAN PERIOD

In the early Silurian time the sea shifted back and forth from the Gulf region as far as southern and central Illinois, but did not return to the Good Hope and La Harpe area before the middle part of the period, during which time it was drained off from the southern part of the State. The Silurian seas were commonly clear and contained abundant animal life which resulted in the accumulation of thick beds of limestone.

DEVONIAN PERIOD

Deposition of Silurian limestone in this region was stopped by the withdrawal of the sea, and the surface of the northern part of the State was subjected to processes of erosion until the latter part of the Devonian period.

The oldest sediments of the Devonian in the Lower Mississippi valley are found south of St. Louis where a part of each of the epochs of the Devonian is represented by deposits. In the northwest part of the State the Devonian sea which invaded from the north was at first clear so that the deposits were limestone. Later a muddy sea covered the region, and a bed of dark shells was spread widely over the eroded surface of the Devonian limestone and of older strata which were covered by this submergence.

In each of the intervals during which the region was above the sea and exposed to weathering and erosion, a part of the sediments previously deposited were washed away. As a result of the breaks in the continuity of deposition, and also of the removal of a considerable thickness of sediments from the surface during each recurrence of land conditions, the rocks now present in the region constitute only a partial record of deposition during the Paleozoic periods.

MISSISSIPPIAN PERIOD

Early in the Mississippian period, a widespread submergence began in the interior of the continent. The earliest Mississippian sediments were mostly mud with some sand and calcareous material which became the present

Kinderhook formation. They were laid down upon the greatly eroded surface of the Devonian shale, or upon still older formations where the Devonian was absent. Following the Kinderhook deposition the sea became clear and the sediments that accumulated on the sea bottom consisted largely of remains of crinoids and other lime-secreting organisms that flourished in great profusion, and make up the Burlington limestone. Deposition of limestone-forming sediments continued through the Keokuk time, but was interrupted for a time at the end of the Keokuk while the muddy sediments that constitute the Warsaw beds were accumulated. In the southern part of the State shiftings of the shore line are indicated by breaks in sedimentation, one of which occurred just before, and another just after, the deposition of the Salem limestone, and a third break is present in the midst of the St. Louis formation.

The St. Louis limestone is the latest record of Mississippian deposition preserved in this region, although it is probable that the Ste. Genevieve limestone was originally present above the St. Louis, since it is known to occur some distance farther north, in Iowa. During the latter part of the Mississippian period the interior sea gradually withdrew southward from the Mississippian basin, the Chester group of shales, and sandstones, and shaly limestones being found in the State only in the south part where they lie uncomformably upon the older Mississippian formations. The exact time when the sea retired from the Good Hope and La Harpe area is not known as the latest Mississippian strata laid down in the area were removed by erosion before the next advance of the sea, and have left no record of their extent or character. The warping movements which resulted in the relative uplift of the land, and caused the sea withdrawal, were so nearly uniform over extensive areas that they caused but little folding, and the sedimentary beds were only slightly disturbed.

PENNSYLVANIAN PERIOD

Land conditions similar to those which prevailed during the latter part of Mississippian time continued in this region during the early part of the Pennsylvanian. The processes of solution and erosion had been active for so long a time that the region was a low lying plain, and judging from the neighboring areas in which the Mississippian limestones now immediately underlie the surficial material, the surface was pitted with sink holes, numerous caverns were dissolved in the limestones, and a part of the drainage found its way to the major streams through underground channels.

In the latter part of the Pottsville epoch after thousands of feet of Pennsylvanian sediments had been deposited in the southern part of the Appalachian basin, and in Arkansas and Oklahoma, and hundreds of feet in northwestern Kentucky and southern Illinois, the sea slowly advanced from the south, reaching the Good Hope and La Harpe region in late Pottsville time. The subsidence was accomplished without conspicuous warping, folding or faulting. The sands, clays, and thin coal beds of the Pottsville formation were deposited upon the eroded surface of the Mississippian rocks which they overlapped in places at the north nearly as far as the latitude of Hampton, Mendota, and Joliet. Outliers of Pottsville rocks in Whiteside County indicate that the maximum northward extent of this sea was at least 25 miles north of Rock Island, and it was probably considerably farther. As the submergence progressed, the muds and sands that were spread by the waves filled the depressions in the subsiding land surface. By the time the Pottsville sea reached the Good Hope and La Harpe area the bordering lands had been worn so low that they contributed only small amounts of coarse sediments so that muds and sandy clays were the prevailing types of Pottsville sediments in this region, which was in strong contrast to the thick beds of sandstone that make up the Pottsville beds in the southern part of the State.

However, the conditions of deposition were notoriously unstable during the Pottsville, as they were during the later portions of Pennsylvanian time, and the character of the sediments changed rather rapidly in both vertical and horizontal directions. At times parts of the State were above the sea and fresh water marshes of greater or less size became the habitat of vegetation that at death accumulated under the water of the marshes in which it grew and eventually formed beds of coal. During the latter part of the Pottsville, extensive marsh conditions prevailed at least once in this region when the vegetable matter accumulated from which the Rock Island (No. 1) coal bed was formed.

During the succeeding Carbondale time intervals of marine deposition alternated with long periods during which extensive fresh water marshes prevailed over the areas formerly covered by the Pottsville sea. The accumulations of vegetable matter in these marshes have been compressed and transformed into the coal seams of the Carbondale formation, of which the most important are the Murphysboro (No. 2), the Springfield (No. 5), and the Herrin (No. 6) beds. Of these only the former is present in the La Harpe and Good Hope quadrangles. Early in the Carbondale time the vegetation from which this coal was formed flourished over a shallow swamp that covered the larger part of central and southern Illinois, northern Missouri, and adjacent areas. After the accumulation of many feet of peaty matter a more rapid subsidence of the region permitted the incursion of the sea which killed the vegetation and buried the plant deposit beneath sand and mud. Only the lower part of the Carbondale sediments have been preserved from erosion in this region, hence there is left here no sedimentary record of the latter part of the Carbondale or of any part of the succeeding McLeansboro epoch which closed the Pennsylvanian. It is known, however, from the sediments of these epochs that have been preserved farther south and west in the State, that variable deposition of muds, sands, thin, calcareous sediments, and at times vegetable deposits continued throughout Carbondale and McLeansboro time over the greater part of central and southern Illinois. Near the close of the Pennsylvanian period, warping movements occurred which resulted in the permanent banishment of the sea from the region.

POST PENNSYLVANIAN DEFORMATION

Following the deposition of Pennsylvanian sediments, warping movements started which marked the beginning of the uplift that culminated in the elevation of the Appalachian mountains on the east, and the Ozark dome and Ouachita mountains on the west and the further upbowing of the La Salle anticline in Illinois. This disturbance, which affected the greater part of eastern North America, deformed the rocks in the Good Hope and La Harpe quadrangles but little. Many of the minor structures that are found in the strata of Illinois were doubtless produced during this time, but they are so broad and low as to be scarcely distinguishable from irregularities of deposition. However, the general altitude of the surface was considerably increased, the region being elevated from near sea level to a position a few hundred feet above the sea.

Mesozoic Era

This region was land and its surface was subjected to erosion throughout all of Mesozoic time. Early in the era hills and valleys were carved in the recently elevated plain, resulting in the development of considerable relief. After the larger streams had cut down to base level, they widened their valleys and developed increasingly complex systems of tributaries which cut back constantly farther and farther into the divides. Slowly the higher parts of the uplands were reduced and the divides lowered, and if the process was not interrupted by uplift, the entire region again became a nearly level plain, at a lower elevation than before. Probably relative uplifts of the region occurred from time to time repeatedly starting anew the down cutting of the streams and greatly delaying if not entirely preventing the complete development of the final stage of the erosion cycle.

Cenozoic Era

During the Mesozoic and Cenozoic eras several uplifts are known to have occurred on the continent resulting in further uplifts in the older areas of disturbance, and producing important mountain elevations in the western parts of the continent. The effects of these movements were doubtless felt in the Good Hope and La Harpe quadrangles though the changes were slight, as is shown by the absence in the area of any pronounced faults or folds. No distinct evidences of downward movements were found in this region.

TERTIARY PERIOD

No deposits of this time are known in the Good Hope and La Harpe quadrangles, and those that are present in the neighboring region accumulated on the land, not in the sea. The history of early Tertiary time in this area can be inferred in a general way from the events that took place in other parts of the continent. By late middle Tertiary time the region is thought to have been again nearly peneplained by erosion, as is indicated by the nearly level character of the upland rock surface beneath the glacial till. Near the close of the Tertiary a general uplift of this region rejuvenated the streams, and permitted the development of the valleys that were cut in the hard rock in many places 100 or more feet below the tops of the divides of that time. Records of well borings in the area show that the maximum relief of the rock surface in the quadrangles before the glacial till was spread over it exceeded 300 feet but except in the deepest valleys it was not more than 75 feet, on the average.

PREGLACIAL TOPOGRAPHY

The general character of the preglacial surface is shown in the sketch map, Figure 9, on which the high rock areas or belts of preglacial upland ranging in elevation from 650 to 750 feet are shaded, and the unshaded areas represent lowlands of the bed rock surface over which the elevation ranges between 530 and 650 feet. From the map it may be seen that a broad preglacial ridge or highland extends in a general north-south direction along the east part of the La Harpe quadrangle and the west part of the Good Hope area. This area is widest at the north, and much of it lies above 700 feet, one place reaching an elevation of 763 feet.

A few miles south of Stronghurst a buried ridge of rock extends west from this main highland for a distance of 6 or 8 miles, and another less conspicuous ridge juts westward a few miles north of Blandinsville. Between these watersheds or divides the surface of bed rock declines more than 100 feet. The general slope and drainage on the west side of the main highland was towards the west and southwest, and on the east of the rock highland the surface declined toward the southeast.

Apparently the general features of this preglacial topography were much similar to the present, although some exceptions appear. South of Stronghurst Honey Creek cuts across a buried rock ridge in two places, and 3 or 4 miles still farther south a preglacial valley underlies what is now an upland divide; and the valley of Ellison creek in the north part of the quadrangle is developed over a preglacial upland, while the upland prairie in the vicinity of Bushnell lies over a preglacial lowland area.

QUATERNARY PERIOD

PLEISTOCENE EPOCH

The topography of this region during the Quaternary was developed entirely by stream erosion, while the present topography owes its origin in part to deposition by glaciers, and in part to stream erosion on the surface of the drift sheets. During Quaternary time five different ice sheets invaded northern United States from their centers of accumulation in Canada. Each of these carried great quantities of clay, pebbles, and boulders, which were deposited when the ice melted.

The movement of the glaciers over the region smoothed off and lowered the hills and more prominent elevations and the deposition of glacial debris more or less completely filled the preglacial valleys so that the general effect of the glaciation was to smooth off and reduce the relief of the surface.

This first ice sheet known to have advanced from the north over the Good Hope and La Harpe area, was the second of the group of five and is known as the Kansan. During the Yarmouth interglacial stage which followed the melting of the Kansan ice sheet, the surface of the drift became covered with vegetation and in places suffered considerable erosion, and alluvial deposits were formed in the larger valleys.

After the long Yarmouth stage of mild interglacial conditions another ice sheet, the Illinoian, advanced southwestward from its center in Labrador, and overspread the larger part of Illinois, bringing with it clay and pebbles and boulders of rock common in Labrador and the intervening territory. As it moved forward it gathered up much of the Yarmouth soil and the till left by the Kansan glacier, and mixed them with the debris brought from farther north. In a few places, however, it overrode and buried the Kansan drift and the old soil that had been developed upon it without greatly disturbing either. When the Illinoian glacier melted it left a second mantle of drift which completely buried the hills and valleys developed in Yarmouth time, and left the surface fairly level. The prairies that form the interstream divides in this region were formed at this time. They may have been somewhat lowered by erosion during subsequent Sangamon and Iowan time, but their heights in most places have been increased a few feet by deposition of loess.

Upon the surface of the Illinoian drift new lines of drainage were gradually developed and on the more level areas a dark soil was formed from the residual organic matter derived from successive generations of plants that grew upon the surface. This soil horizon, which has been named Sangamon, contains in places much peaty material and fragmentary wood. On the slopes where leaching and erosion were active during Sangamon time organic matter was not allowed to accumulate and a dark soil is absent.

After the Sangamon interglacial conditions had existed for a long time, and the development of the present valleys was well advanced, another ice sheet known as the Iowan, advanced into the upper Mississippi valley although it did not cover the Good Hope and La Harpe quadrangles. During the latter part of the Iowan stage of glaciation, or soon after this ice sheet melted, conditions became unusually favorable for the accumulation of extensive deposits of dust. This dust, named loess, was spread over the Sangamon soil and over the leached and eroded Illinoian till where the Sangamon soil was absent. Later dust transportation diminished, and became overbalanced by erosion, and the processes of valley development continued without marked interruption to the end of the Quaternary period.

RECENT EPOCH

During Recent time the altitude of this region has not been appreciably changed, though northeast of Illinois there is evidence of slight warping movements which affected the Great Lakes area. The principal events have been the removal by erosion of a part of the material deposited during the Pleistocene epoch, and the related lengthening, deepening, and widening, of the valleys, and the further development of flood plains. In carving their channels on the surface of the Illinoian drift the streams reached bed rock first where they crossed the preglacial divides, and as they continued to deepen their channels they cut into these buried ridges, exposing the hard rock in their banks. In other places they have not yet reached the bottom of the drift.

MINERAL RESOURCES

The principal mineral resources of the Good Hope and La Harpe quadrangles are clay and shale, coal, stone, sand, and gravel. Besides these there should be mentioned water which is easily found everywhere in the region, and the soil which is the chief source of wealth in the area.

Clay and Shale

The manufacture of clay products is an industry which has not been developed in the Good Hope and La Harpe quadrangles up to the present time. Valuable deposits of Pottsville clay are being worked just south of the Good Hope and La Harpe area, near Macomb and Colchester, and it is not unlikely that deposits of similar character occur within the Good Hope and La Harpe quadrangles. Such deposits are, as a rule, poorly exposed along the streams and must be discovered by careful prospecting. The areas in which such prospecting should be carried on are pointed out below.

Three types of material are available for the manufacture of clay products: (1) Loess and glacial drift clays, from which common brick and tile may be made, (2) shale from the Carbondale formation, which is suitable for the manufacture of brick, tile, building blocks, silo blocks, and similar products, and (3) clay and shale from the Pottsville formation, which is valuable for the manufacture of sewer pipe and stoneware of various kinds. The loess and drift clays occur almost everywhere directly beneath the soil, particularly on the uplands, and can be easily developed wherever there is a demand for common brick and tile. Shale from the Carbondale formation varies considerably in character from place to place and should be tested to determine the products for which it is best suited. Such shale is exposed at the following localities: (1) along Big Nigger Creek in secs. 7, 8, and 9 in Swan Township (T. 8 N., R. 2 W.); (2) along Swan Creek in secs. 10, 15, 16, 17, 18, 19, and 20 of the same township, and secs. 16 and 17 in Greenbush Township (T. 8 N., R. 1 W.); (3) along Crooked Creek in sec. 9, Walnut Grove Township (T. 7 N., R. 2 W.); (4) along Spring Creek in secs. 5 and 6, Emmet Township (T. 6 N., R. 3 W.); (5) along La Harpe Creek in secs. 21 and 22, Blandinsville Township (T. 7 N., R. 4 W.); and (6) along Baptist Creek in sec. 34, in the same township, and in sec. 4 of Hire Township (T. 6 N., R. 4 W.).

Clay from the Pottsville formation should prove the most valuable if extensive deposits can be discovered. The most valuable horizon in the formation is that of the stoneware clay, which lies 15 to 25 feet below the Murphysboro coal and a few feet above the Rock Island coal bed. This clay was formerly mined along the south side of Crooked Creek in secs. 14 and 15, Macomb Township (T. 6 N., R. 2 W.), but none has been taken out in recent years.

A promising exposure of shale was found along Baptist Creek, where the following section was measured:

Section of Pottsville rocks measured in sec. 6, T. 6 N., R. 4 W. (Hire)

		Thickness	
		Ft.	*In.*
13.	Glacial till	3	6
12.	Sandstone	..	2 to 6
11.	Clay-shale, gray, becoming black towards base	19	..
10.	Coal	..	¼ to 12
9.	Sandstone, lensing out laterally	..	4 to 7
8.	Shale, gray, sandy	4	..
7.	Limestone, black, pyritic, concretionary	..	3
6.	Shale, soft, black	..	6
5.	Limestone nodules, containing sphalerite	..	2 to 6
4.	Shale, soft, black	..	6
3.	Limestone nodules, like (5)	..	2 to 6
2.	Shale, soft, black	..	4 to 6
1.	Sandstone (base not exposed)	2	..

The clay-shale member, No. 11 above, of which there is a considerable quantity under thin cover, deserves prospecting.

The horizon of stoneware clay was reported in the log of an abandoned shaft about 4 miles east and ½ mile north of La Harpe at an altitude of about 638 feet.

Log of old coal shaft 4 miles east and ½ mile south of La Harpe

	Thickness *Feet*	Depth *Feet*
Clay, with pebbles	22	22
Shale, blue	12	34
Shale, gray to bluish	15	49
Coal (No. 2)	3	52
Under clay	4	56
Shale	12	68
Clay, white (stoneware clay)	7	75
Shale, dark, with streaks of limestone	6	81
Coal (No. 1) thin band	..	..

This white clay horizon was encountered in another old coal shaft in the N. ½ sec. 29, Blandinsville Township (T. 7 N., R. 4 W.), as shown in the following log:

Log of shaft 2 miles north of Blandinsville

	Thickness *Feet*	Depth *Feet*
Clay with pebbles	23	23
Sand	1	24
Shale, dark	1	25
Shale, gray	15	40
Coal (No. 2)	2½	42½
Underclay	3½	46
Shale, blue	10 to 12	57
Clay, white (stoneware clay)	4	61
Shale	6	67
Limestone, dark (cap rock of No. 1 coal)	1+	68

The white clay horizon noted in the logs of coal shafts given above is doubtless the same as the stoneware clay worked at Macomb and Colchester a few miles farther south. There is little doubt that it is present in several places in the southeast quarter of the La Harpe quadrangle, and it may also occur in places in the southern part of the Good Hope area. The extent of this clay in the quadrangles can be determined only by careful prospecting.

Prospecting should also be carried on at the following localities, where Pottsville shales are known to occur: (1) along Swan Creek, in the S. ½ secs. 10 and 11, near the center of sec. 12, and in the NW. ¼ sec. 15, Swan Township (T. 8 N., R. 2 W.); (2) along Crooked Creek, in secs. 14 and 15, Macomb Township (T. 6 N., R. 2 W.); (3) along Baptist Creek, in the S. ½ sec. 6 and the NW. ¼ sec. 7, Hire Township (T. 6 N., R. 4 W.); (4) in the NE. ¼ sec. 12, and along a ravine in the NW. ¼ sec. 13, Fountain Green Township (T. 6 N., R. 5 W.); (5) along Little Creek, in the SW. ¼ sec. 31, Blandinsville Township (T. 7 N., R. 4 W.); (6) along a ravine in the SE. ¼ sec. 25, and along Ellison Creek in the E. ½ sec. 29, Ellison Township (T. 9 N., R. 3 W.).

Further descriptions of the clay and shale deposits of western Illinois, and of tests of clay samples may be found in previous reports of the Illinois State Geological Survey.[1, 2]

COAL

Of the four or more known coal beds in this region, the Rock Island (No. 1) and the Murphysboro (No. 2) are the only ones that have been utilized. One or two thin Pottsville coals lying below the horizon of the Rock Island bed are locally present. Of all these coals only the Murphysboro has been mined to any important extent in the area.

POTTSVILLE COALS

ROCK ISLAND (NO. 1) COAL

The Pottsville coals are not here to be considered as productive beds. The Rock Island coal has been mined extensively in Rock Island and Mercer counties, along Spoon River in Fulton County, and to a less extent in the area south of Monmouth, but is not known to have been more than locally productive in this immediate area. It has been reported in a few borings, and in the vicinity of Roseville and Swan Creek is said to lie 30 to 40 feet below the Murphysboro bed, but no outcrops were found which could be identified definitely as the Rock Island coal. A thin streak of coal which may represent this bed was found about 30 feet below the Murphysboro seam in the north bank of Swan Creek about two miles north of Youngstown where the following section was measured:

Section measured in the NW. ¼ sec. 15, Swan Township (T. 8 N., R. 2 W.)

	Thickness	
	Ft.	*In.*
4. Shale, gray	20	
3. Coal (No. 1?)	..	2
2. Shale, gray	1	..
1. Sandstone	..	6

About 400 yards downstream from this exposure the Murphysboro coal outcrops at an elevation of 685 feet. About two and one-half miles west of this place a test boring was put down in the bottom of the old Stansfield shaft north of Swan Creek by Mr. Joe Simpson, who reports two coal beds below the Murphysboro coal in the position indicated by the following log:

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[1] Lines, E. H., Pennsylvanian fire clays of Illinois, and Hinds, Henry, Geology and economic resources of Colchester and Macomb quadrangles: Illinois State Geological Survey Bull. 30, pp. 61-73, and 75-108, 1917.

[2] Stull, R. T., and Hursh, R. K., Tests on clay materials available in Illinois coal mines: Illinois Coal Mining Investigations Bull. 18, 1917.

Log of shaft and boring in the NW. ¼ sec. 17, Swan Township (T. 8 N., R. 2 W.)

Elevation of top of shaft, 730 feet.

	Thickness		Depth	
	Ft.	*In.*	*Ft.*	*In.*
Glacial drift	10	..	10	..
Shale and slate	60	..	70	..
Coal (No. 2)	2	6	72	6
Shale	33	..	105	6
	2	..	107	6
(No. 1?)	2	..	109	6
	2	..	111	6
Soapstone and shale	30	..	141	6
Coal	1	6	143	..

The coal at 70 feet is undoubtedly the Murphysboro, and the 6 feet of coal and fireclay at 107 feet represents the horizon of probably the Rock Island bed, although in other places it is not known to contain a fireclay parting. The thin coal bed at the bottom of the boring is a Pottsville coal which may be tentatively correlated with a thin coal which outcrops along Cedar Creek near the northern limit of the Good Hope quadrangle. At that locality it lies a few feet below a white sandstone, containing carbonized root impressions, which is known to occur commonly below the Rock Island coal. The coal is only 8 to 10 inches thick at the outcrop, probably occupies small basins, and is of little or no economic importance. Both the roof and floor are composed of sandstone or sandy shale.

Southwest of Blandinsville, in the La Harpe quadrangle, are several outcrops of a Pottsville coal which varies from a fraction of an inch to about a foot in thickness. It probably represents a third coal horizon below the Rock Island bed, since it lies near the base of the formation, only a few feet above the St. Louis limestone. Outcrops were noted in the SW. ¼ sec. 12, and the NW. ¼ sec. 13, Fountain Green Township (T. 6 N., R. 5 W.); in the road on the county line between sec. 7, Hire Township (T. 6 N., R. 4 W.), and sec. 12, Fountain Green Township (T. 6 N., R. 5 W.), and in several ravines along Baptist Creek in the SW. ¼ sec. 6 and the NW. ¼ sec. 7, Hire Township (T. 6 N., R. 4 W.). Although this coal may thicken locally and become workable in a small way, it cannot be considered an important bed.

CARBONDALE COALS

MURPHYSBORO (NO. 2) COAL

The Murphysboro coal is the principal workable bed in this area. It underlies a considerable portion of the Good Hope quadrangle, and a large area in the southeast part of the La Harpe. In the area mapped as coal land, however, there are doubtless some tracts where the coal was removed by preglacial erosion, which are not known at present on account of the thick mantle of glacial drift which obscures the outcrops. Likewise, outside of the area indicated as coal land, a few patches of coal may exist which are covered and entirely surrounded by drift. This coal is usually thin, seldom exceeding 30 inches in thickness, and probably cannot be mined with profit at the present time. It is only along or near the streams, where it outcrops or lies near the surface that the bed has been utilized.

SPRINGFIELD (NO. 5) COAL

Although the Murphysboro coal is the only bed of apparent importance, another coal higher in the Carbondale formation has furnished a little production in the past. It outcrops north of Swan Creek in a small ravine on the west side of the road, near the SE. ¼ NE ¼ sec. 18, Swan Township (T. 8 N., R. 2 W.), where a drift was driven into the bank some 40 years or more ago. In recent years the mine has been reopened and a little coal removed from old pillars and unworked portions. It is said that the best part of the coal, varying from 2½ to 4 feet in thickness, has been taken out, but that a considerable amount of thinner coal, from 1½ to 2½ feet thick, remains. The coal is said to be of good quality, but is difficult to mine on account of its erratic dip and its irregular thickness. In some places it thickens to a maximum of about 4 feet, but in others it pinches out entirely. The roof is said to consist of black shale. At the outcrop it lies at an elevation of 740 feet, or about 80 feet above the Murphysboro bed as indicated by the log of the Stansfield shaft, just across the road from the outcrop.

This bed was referred by Worthen, in his early work in this region, to No. 3 coal, but it is probable that it corresponds to the Springfield (No. 5) coal of Fulton County. In Fulton and Schuyler counties the interval between No. 2 coal and No. 5 coal is usually 100 feet or more, but since the Swan Creek locality lies very near the western edge of the Illinois basin, and the Pennsylvanian strata converge towards the edge of the basin, an interval of only 80 feet between the two coals is no less than might be expected. It is probable that this coal is present in the area over only a few acres in the Good Hope quadrangle.

SANDSTONE

The Pottsville sandstone, outcropping along Cedar Creek, in the northeast part of the Good Hope quadrangle, and along Big Nigger Creek in sec. 1, Swan Township (T. 8 N., R. 2 W.), in the same quadrangle, affords a fairly good building stone. Some stone has also been taken from an old quarry in the SW. ¼ sec. 21, Berwick Township (T. 9 N., R. 1 W.), for local use in foundation walls, bridge piers, flagging, well curbing, and similar work. Considerable quantities of stone are still available at both of these localities, where the rock stands in bluffs 15 to 25 feet high.

LIMESTONE

The only limestone in the region which is suitable for commercial use occurs in the western part of the La Harpe quadrangle where Mississippian limestones are exposed at the surface. Along Honey Creek and its tributaries south and west of Stronghurst are many outcrops of Burlington limestone, suitable for rough building purposes. A few quarries were worked some years ago and the rock was used locally for the construction of barns, foundation walls, bridge piers, and similar purposes; but very little has been taken out in recent years.

Finely-crushed limestone of high quality for fertilizing purposes can readily be obtained from some of the beds of Burlington limestone along Honey Creek, if care is taken to exclude the chert bands which are frequently interbedded with the pure limestone. Material for use of this sort has been shipped in from Burlington, Iowa, and elsewhere, but the demand could be supplied locally.

Crushed stone for concrete material and road metal can likewise be obtained from the same region. At many localities south of La Harpe, along La Harpe, Little, and Baptist creeks, St. Louis limestone might be crushed and used for similar purposes.

LIME

Some portions of the St. Louis limestone, at the localities referred to above, contain a very high percentage of calcium carbonate and could well be used for the manufacture of lime. Probably the best material for this purpose, however, is the Burlington limestone, some beds of which are composed of almost pure calcium carbonate, and have as low as 1 to 2 per cent of impurities. If the chert bands are carefully excluded a very high quality of product might be obtained.

SAND AND GRAVEL

Sand and gravel deposits of limited extent occur at many localities within the two quadrangles. In view of the modern tendency toward the building of hard roads the sand and gravel resources of the area are of considerable importance. Although many of the deposits are doubtless small, none should be overlooked in as much as when hard roads are to be built a local supply of road material is a valuable asset.

Along the valley of Swan Creek in the Good Hope quadrangle are many exposures of sand and gravel. In the NW. ¼ sec. 15, Greenbush Township (T. 8 N., R. 1 W.), along the north bank of the creek the following section was measured:

Section measured in NW. ¼ sec. 15, T. 8 N., R. 1 W.
(Greenbush)

	Thickness *Feet*
Loess	6
Sand, fine, white and yellow	10
Gravel, coarse	2 to 3
Shale, black	5

The gravel is composed almost entirely of very resistant rocks, principally chert and quartz, and it should make excellent road metal. It may be regarded as typical of the gravel throughout the region. At some localities there is a larger percentage of igneous and metamorphic rocks, such as granite, diabase, or quartzite, but chert and quartz always greatly exceed the other rocks in amount.

A bed of gravel, similar to that just described, is exposed at many places along the south bank of Swan Creek in the N. ½ sec. 16, Greenbush Township (T 8 N., R. 1 W.), for a distance of half a mile or more. Farther west, in the SE. ¼ sec. 10, Swan Township (T. 8 N., R. 2 W.), an exposure of about 7 feet of coarse sand and gravel occurs along the south bank of the same creek.

In the north bank of Swan Creek, near the center of sec. 17, Point Pleasant Township (T. 8 N., R. 3 W.), gravel in beds 10 to 15 feet thick is exposed. It lies near the top of the hill with only a thin overburden of soil. For some distance west of this place along both banks of the creek, in the S. ½ sec. 18, and the N. ½ sec. 19, sand and gravel of excellent quality in beds 5 to 15 feet thick is exposed. A short distance north of the road, in the NW. ¼ sec. 19, a small pit has been opened and some gravel removed. Occurring as they do less than a mile from the Monmouth and Macomb road, one of the principal highways of the region, these deposits form an important resource of road-material. They also contain considerable quantities of sand suitable for a building sand.

Along a small ravine on the north side of Little Swan Creek, in the NE. ¼ sec. 19, Greenbush Township (T. 8 N., R. 1 W.), the following section was measured:

Section measured in the NE. ¼ sec. 19, T. 8 N., R. 1 W. (Greenbush)

	Thickness	
	Ft.	*In.*
Loess, very sandy	2	..
Sand, brown, coarse and clean, with a little fine gravel	5	..
Sand, red to reddish-brown, clean and coarse	4	6
Clay, white, sandy	2	..
Clay, brown, cross-bedded	..	6
Sand, quartz, white and clean	3+	..
Sand, brown and white, poorly exposed	5 or 6	..
Clay, white, or yellow, very sandy	12 to 15	..

CEMENT ROCK

Materials suitable for the manufacture of Portland cement outcrop in and near the Good Hope and La Harpe quadrangles, although no outcrops are known where both the clay and the limestone could be worked in close proximity. Analyses of samples of St. Louis and Keokuk limestones taken from near the La Harpe area show that in great part these limestones are suitable for making Portland cement, and there is no doubt that equally good limestone from these formations outcrop within the La Harpe area. The Burlington limestone exposed in this area is commonly very pure, and would make equally good cement rock. In most places where they outcrop, the shale in the upper part of the Pottsville formation, and that above the Murphysboro (No. 2) coal could probably be used for making cement. Pleistocene clays, as loess and glacial till such as are used to supply the clay component of the raw mix in the Sandusky cement plant at Dixon, Illinois, are present in abundance in many places in the quadrangles.

METALLIC ORES

IRON, ZINC, AND OTHER METALS

Coarse gravel and sand in the glacial drift is often stained with iron hydroxide and at times is so thoroughly cemented with limonite (brown iron ore) as to form a hard conglomerate. In one or two instances this material has given rise to belief in the presence of a valuable deposit of iron ore. Samples of such material from a small ledge along Crooked Creek, in the SE. ¼ of sec. 8, Walnut Grove Township (T. 7 N., R. 2 W.), McDonough County, were sent to a chemist by the land owner, and were reported to have a high iron content, but not sufficiently high to be classed as iron ore. However, the ledge is only about two feet thick and extends only a few yards laterally, so that even if the iron content were higher, the amount available is too small to give the deposit commercial value. A similar deposit about 5 feet thick occurs near the center of sec. 16, Raritan Township (T. 8 N., R. 4 W.), in Henderson County. Here also the extent of the conglomerate is limited to only a few yards laterally.

Ferruginous nodules and layers of iron carbonate, similar to the "clay ironstone" of the eastern United States, occur in the Pennsylvanian shales at a few localities, but they are never more than a few inches in thickness.

The presence of zinc and lead ores has been reported from this region in a number of instances, both in rock outcrops along the streams, and in drill cuttings from deep wells. In every case where the writer was able to obtain samples of the so-called ores they consisted of crystals of sphalerite, a sulphide of zinc (zincblende or "black-jack"). The material was found outcropping along Baptist Creek southwest of Blandinsville in the SW. ¼ sec. 6, Hire Township (T. 6 N., R. 4 W.), where a thin lenticular coal bed, varying from less than an inch to a foot in thickness, outcrops in the creek bank. Four feet below the coal is a layer of rounded nodules of black ferruginous limestone from a fraction of an inch to 12 inches in diameter. Six inches below that is another similar layer and 6 inches below that is a third. They occur in the lower part of the Pottsville formation only a few feet above the top of the St. Louis limestone. When broken open many of the nodules, or concretions, are found to contain large crystals of calcite and sphalerite. The largest sphalerite crystals seen measured about 2 inches across. The presence of distorted shells of brachiopods *(Productus sp.* and *Spirifer sp.)* show that the material of the nodules was originally deposited as lenses of calcareous mud. As this material became compacted, shrinkage cracks were formed in which calcite and sphalerite crystals were deposited by percolating water. The crystals grew by addition of material from without, probably by a process of solution and deposition rather than by an actual molecular replacement of the limestone, until in some cases as much as half of the nodule is replaced by sphalerite. The zinc was probably concentrated from the surrounding shale and limestone, in which small amounts of the metal occur, through the action of percolating water. The actual amount of sphalerite is very small, compared to the amount of rock which it would be necessary to mine in order to recover the zinc, and it is not probable that deposits of commercial size are present.

No lead minerals were seen by the writer, and it is likely that the so-called lead ore which has been reported is in reality sphalerite. Water wells are frequently drilled through the horizon of shale in which the sphalerite occurs, and it is probable that the reported ores were obtained from concretions such as those described above, or from geodes in the Warsaw shales.

Native copper, gold, and other minerals are sometimes found associated with the gravel and boulders in the glacial drift, and in some cases have led to the belief in the presence of valuable ore deposits. However, these materials have all been transported for great distances by glaciers and the ledges from which they were obtained lie hundreds of miles to the north, so that the presence of nuggets or fragments of these ores in the drift has no economic significance.

Oil and Gas

The Good Hope and La Harpe quadrangles are only a few miles north of the Colmar oil field in which stratigraphic and structural conditions similar to those in the quadrangles are found, suggesting the possibility that production may be found there.

POSSIBLE OIL-BEARING HORIZONS

Four possible oil-bearing horizons in the rocks underlie the Good Hope and La Harpe region. These are, in order of depth, the Pottsville sandstone, the Niagaran dolomite (Silurian), the Hoing sand at the base of the Silurian, and the Galena-Platteville limestone or dolomite (Ordovician).

POTTSVILLE SANDSTONE

Large quantities of oil have been produced from Pottsville sandstones in the northern part of the main oil fields in southeastern Illinois. There, however, the Pottsville formation is thick and contains thick sandstone beds which are persistent over comparatively large areas. In the Good Hope and La Harpe region thick sandstones in the Pottsville are not common, the thickest known being that which outcrops on Cedar Creek at the northeast corner of the Good Hope quadrangle, where the maximum is about 30 feet. Thicknesses of 50 to 75 feet are reported in some wells, but undoubtedly a considerable thickness of shale is included. No oil has been produced from the Pottsville of western Illinois, but oil is reported to have been encountered in a few wells drilled into it in search of water. Mr. John Anderson states that in a well drilled near the NW. cor. SW. ¼ sec. 12, Swan Township (T. 8 N., R 2 W.), in Warren County, a thick black oil was encountered in sandstone at a depth of 75 or 80 feet or 35 feet below the top of the sandstone. A quantity estimated at several barrels of oil is said to have flowed out of the well, but this was finally cased off, and fresh water struck at 90 feet. Two wells drilled in secs. 17 and 18, Ellison Township (T. 9 N., R. 3 W.), in Warren County, are said to have encountered oil at depths of 120 and 100 feet, respectively. However, no considerable production of oil is to be expected from the Pottsville sandstone in this region, owing to its shallowness, thinness, and small lateral extent.

SILURIAN DOLOMITE

The Silurian dolomite is very porous and frequently contains small quantities of gas and oil; gas has been produced from the Niagaran in the Pike County field for many years, and small amounts of heavy, black oil have been reported in the same area. Throughout western Illinois gas is not uncommonly found in wells which penetrate the Silurian. In Henderson County, in the vicinity of Media, gas and showings of oil were encountered in several wells, although no production has been secured.

THE HOING SAND

The Hoing oil sand has furnished all of the oil that has been produced in commercial quantities in the Colmar area. It occurs as lenses immediately above the Maquoketa shale and is usually overlain by Silurian dolomite.

although in some places Silurian strata appear to be absent and Devonian limestone rests directly on the Hoing sand. The sand consists of well rounded quartz grains which appear to have accumulated in depressions on the surface of the Maquoketa and to have been more or less reworked by the waves of the Silurian sea. Because of its lenticular character this sand is very irregular in thickness and distribution, being absent in many places. In the most productive parts of the Colmar field the thickness varies from 5 to 30 feet, and averages 12 to 15 feet.

Since the Hoing sand is not a continuous bed, but occurs in isolated or disconnected lenses, prospecting for oil in it is unusually hazardous, as the presence of the sand cannot be predicted in advance of drilling. It is probably absent over a considerable portion of the Good Hope and La Harpe area, and a search for oil must therefore in large part consist in a search for bodies of the sand. The sand is known to occur at only two localities. One of these is in the new Bushnell well, drilled in 1915, in which about 15 feet of sandstone was reported at the base of the Silurian dolomite and represented in samples of drill cuttings from the well, examined by members of the State Geological Survey staff. The lower eight feet consists of white, quartz sand, and the seven feet above this contains a considerable proportion of sand mixed with dolomite. The second locality in which sand was reported at the base of the Silurian is southeast of La Harpe, where samples of the drill cuttings from a well drilled on the Gochenour farm in the NE. ¼ sec. 3, Fountain Green Township, Hancock County, showed that the basal 15 feet of the Niagaran dolomite contained a considerable amount of quartz sand. Another well was drilled on the Gills farm in sec. 8, Emmet Township (T. 6 N., R. 3 W.), and although no log of the well is available, Mr. Gills reported that about 20 feet of sand was found at the base of the Niagaran, with a showing of gas.

In another well in the NW. ¼ sec. 18, Macomb township (T. 6 N., R. 2 W.), 4 feet of good sand with a showing of oil was reported. Although a well may penetrate to the Maquoketa shale without finding the Hoing sand, it does not necessarily discredit the territory immediately surrounding it, for the known lenses of sand are small in areal extent and one of two adjoining wells may find a good sand and the other miss it entirely. There are numerous instances of this sort in the Colmar pool, where two or more separate lenses occur cutting across the Colmar dome and the Lamoine terrace. Under such circumstances, sufficient drilling must be done to demonstrate the general absence of the sand throughout the favorable area before the structure can be said to be fairly tested.

HORIZONS BELOW THE HOING SAND

Two possible oil-producing horizons lie below the Hoing sand, but neither is regarded as likely to be productive in this region. The first is the Maquoketa shale, in which showings of oil have been reported in western Illinois. In the Indian Refining Company's well on the Walker farm in sec. 9, Roseville township (T. 2 N., R. 2 W.), Schuyler County, oil was reported at a depth of 751 feet, about 74 feet below the top of the Maquoketa, and several gallons are said to have been taken from the well. The second horizon below the Hoing sand which might prove productive is the Galena-Platteville ("Trenton") limestone below the Maquoketa. This rock is frequently dolomitic and porous, and showings of oil have been reported from it. It occupies about the same position in the geological column as the "Trenton" of southeastern Illinois and the Waterloo field in Monroe County from which oil is being produced. The "Trenton" limestone of Ohio and Indiana has been the source of large quantities of oil. The "Trenton" is the oldest known rock in this area in which any oil may reasonably be expected, and since it can be reached at a depth of not over 1,000 feet, testing would be relatively simple and inexpensive.

RELATION OF ACCUMULATION TO FOLDS IN THE OIL-BEARING BED

Studies of oil and gas occurrence throughout the world have demonstrated beyond question the importance of rock structure in determining the accumulation of these substances. Although one can by no means state that all oil occurs in anticlines or domes, experience and careful studies of known oil pools in Illinois have shown that the proper conditions for accumulation in the area under discussion are most likely to be met with at the crests of folds such as anticlines or domes, and that in new territory such places should be tested first.

There are three principal conditions governing oil accumulation. These are:

1. The presence of a porous bed, such as a sandstone or cavernous limestone to serve as a reservoir.
2. An impervious cover, such as shale or other fine-grained rock to prevent the escape of the oil or gas.
3. Folding in the rocks, by which are produced arches or convexities in which the oil and gas can migrate and segregate into pools.

The first condition may be met in this region by any one of the beds described above under the heading "Possible oil-bearing horizons." The second is met by the Maquoketa shale lying above the Galena-Platteville ("Trenton") limestone, the Kinderhook and Upper Devonian shales above the Niagaran dolomite and the Hoing sand, and the Pennsylvanian shales above the Pottsville sandstone. The third condition, that of folding to produce favorable geological structure, is met at certain localities and it is the purpose of this report to point out the areas in which favorable structures exist.

The accumulation of oil in a given structure is to a considerable degree dependent upon the presence and amount of salt water in the sand. The

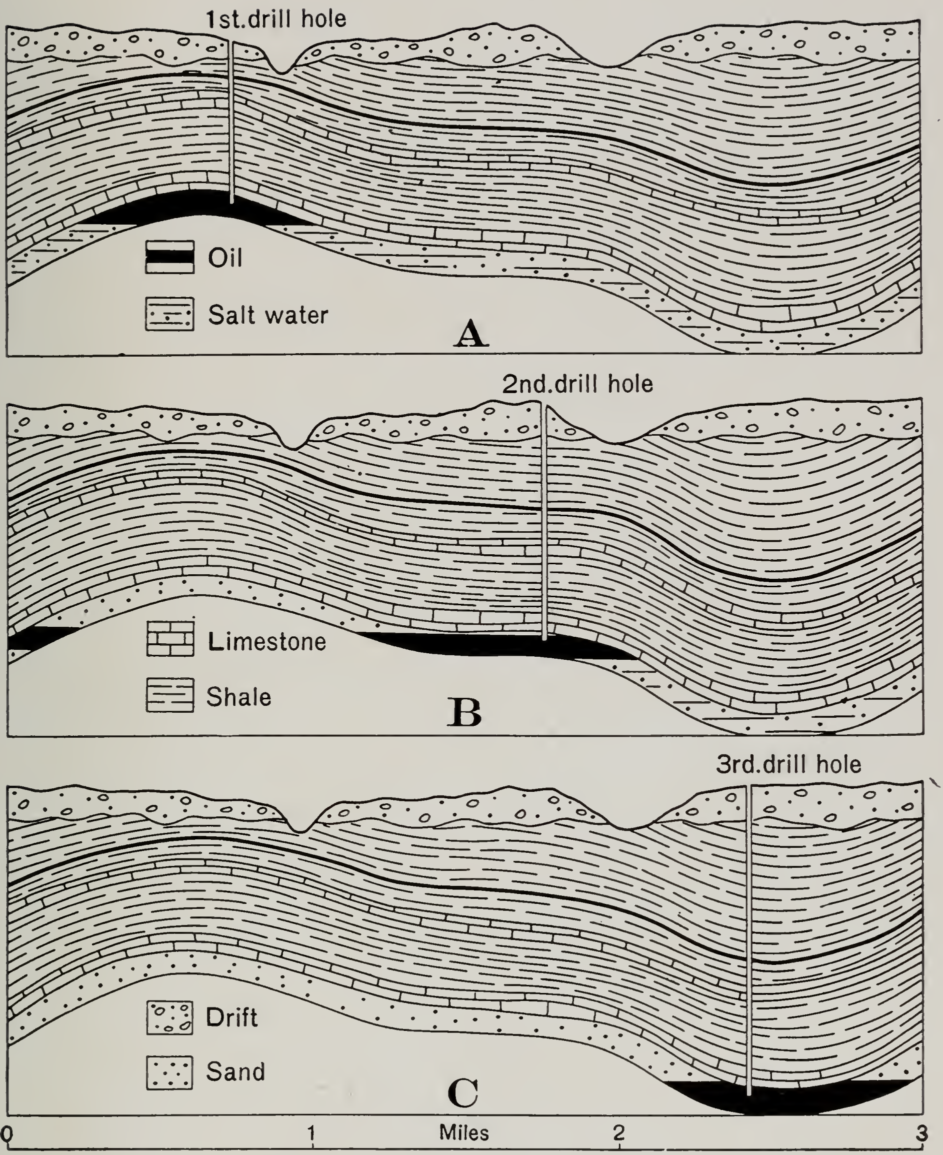

Fig. 11. Diagrams showing conditions governing oil accumulation.
A. In oil sands saturated with water.
B. In oil sands partly saturated.
C. In sands containing no water and only partly filled with oil.

productive oil fields of Illinois are in the main surrounded by barren areas in which the sand contains salt water. Where the sand is saturated the oil lies near the crest of the anticlines or domes, with the gas, if present, above the oil (Fig. 11A). Where the sand is only partly saturated with water the oil lies farther down the sides of the folds, at the upper surface of the water, and the crests may be dry (Fig. 11B). A rather common mode of occurrence is on flattened terraces on the sides of a fold such as is shown in Figure 11B. If water is absent from the sand, the oil may occur in the troughs or synclines (Fig. 11C). This mode of occurrence is comparatively rare and prospecting should be confined to the domes, anticlines, and terraces, unless it is demonstrated that the sand contains no water.

LOCALITIES ALREADY TESTED

Oil was reported as occurring in a number of shallow wells in this region, and ten wells have been drilled to test for oil or gas. These were all purely wildcat wells, however, and with one exception were drilled without reference to the geologic structure. In the Good Hope quadrangle, one of the more favorably located wells, so far as structure is concerned, was the Parrish well in sec. 34, Ellison Township (T. 9 N., R. 3 W.), but it failed to find the Hoing sand.

A well drilled on the George Sailor farm in the NE. ¼ sec. 21, Greenbush Township (T. 8 N., R. 1 W.), is located on very low, probably synclinal structure and found no sand.

A well drilled on the Matt Boden farm in the NW. ¼ sec. 15, Walnut Grove Township (T. 7 N., R. 2 W.), located upon a terrace-like structure, found no sand.

Two wells were drilled on the Hunt and Bruinge farms in sections 7 and 18, Macomb Township (T. 6 N., R. 2 W.). The well in section 18 is reported to have found 4 feet of sand with a small showing of oil. The well in sec. 7 found no sand.

In the La Harpe quadrangle, none of the test wells are considered favorably located as regards structure. Concerning the well one and one-half miles southwest of Sciota, no data are available except that it was a dry hole.

Of the four remaining wells, one in the NE. ¼ sec. 30, Blandinsville Township (T. 7 N., R. 4 W.), and another in the SW. ¼ sec. 25, La Harpe Township (T. 7 N., R. 5 W.), found no sand, and no show of oil. Of the other two wells the Gills test, in the NW. ¼ sec. 8, Fountain Green Township (T. 6 N., R. 5 W.), is reported to have found 20 feet of sand with a showing of gas; and the Gochenour well in the NE. ¼ sec. 3 of the same township (T. 6 N., R. 5 W.) found a showing of sand but no oil or gas.

RECOMMENDATIONS

The proximity of this region to the productive Colmar field, the similarity of geological conditions here and in the Colmar area, and the shallow depth at which production may be expected all combine to make prospecting attractive, but on the other hand the absence of the sand at many localities, and the impossibility of any prediction as to its presence makes prospecting unusually hazardous.

Since the presence of the sand cannot be predicted even in a general way, the logical method of procedure is to drill first those areas in which at least one of the factors governing the accumulation of oil and gas, namely geologic structure, is known to be favorable. Favorable structures are indicated upon the accompanying structure maps. Those which seem worth testing are (1) the large dome in the northern portion of the La Harpe quadrangle, in the vicinity of Stronghurst, (2) the high structure west of Roseville, (3) a terrace east of Roseville, (4) a small terrace dipping gently to the south from the terrace last mentioned, and (5) the suggested terrace-like structure northeast of Good Hope.

GAS IN THE GLACIAL DRIFT

Small quantities of gas are frequently encountered in pockets of sand in the glacial drift. In a water well in the SW. ¼ sec. 9, Swan Township (T. 8 N., R. 2 W.), gas rises in bubbles through the water in such quantities that when a pipe is inserted through the well platform the gas can be ignited with a match and burns freely. Small quantities of gas have been reported in a number of other shallow water wells. In all cases of this sort the gas was probably derived from the decomposition of organic matter buried in the glacial drift and no great quantity is to be expected. This gas has no connection with the accumulation of oil or gas in the underlying rock strata and should not be confused with true oil seeps or gas escapages from solid rocks. It gives no indication whatever of the presence of oil or gas in the deeper strata.

Water Resources

RURAL SUPPLIES

The rural water supplies in this area come from five principal sources, (1) streams, (2) springs and shallow wells, dug or bored in the glacial drift, (3) wells which penetrate the Murphysboro (No. 2) coal, (4) wells in the Pottsville sandstone, and (5) deep wells in the Burlington limestone. A few wells in the southwestern portion in the La Harpe quadrangle obtain water from a thin sandstone in the Salem limestone, but the horizon does not constitute an important source of supply. One or two deep wells obtain water from the Niagaran dolomite, but they were drilled in search of oil and were converted into water wells when they failed to find oil. A third minor source is rain-water collected in cisterns and used principally for laundry purposes. In a few places where well-drilling is expensive, rain-water is used for drinking purposes.

Surface water from streams is rarely used for domestic purposes, but it forms an important source of supply for stock, and many cattle and hogs and a few sheep are raised in the rolling country along the larger creeks.

By far the most important source of domestic water supply is from lenses or layers of sand and gravel in or associated with the glacial drift. Except for the few areas mentioned below in which some water is obtained from the hard rock formations almost the entire rural population depends upon shallow wells in the drift for its water. Wells dug or bored almost anywhere obtain ample water for domestic purposes at depths of 15 to 50 feet, although they are occasionally sunk to 100 feet or more. The water of most of these wells comes from beds of sand or gravel in the drift, but in some wells the glacial till is very sandy and furnishes sufficient water for domestic supply, particularly along the valleys where the water table lies close to the surface. The character of the water from the drift is shown by the analyses in Table 2 of water from shallow wells at Bushnell and La Harpe.

The water of a few springs along the larger streams, as Swan Creek in Greenbush Township, and Crooked Creek in Walnut Grove Township, comes from beds of sand or gravel in the drift, which serve as reservoirs for the surface waters. The springs are in some cases cleaned out and used as a water supply to avoid the expense of putting down wells.

In the region west and southwest of Roseville, in Ellison and Point Pleasant townships, the Murphysboro coal lies only 30 to 80 feet below the surface over large areas, and as that level ordinarily contains considerable quantities of water many wells have been dug or bored to the coal and domestic water supply obtained.

In the northeast part of the Good Hope quadrangle, in Berwick, Greenbush, and the east half of Roseville townships, Pottsville sandstone lies at a comparatively shallow depth, and many wells are drilled into it. The sandstone is generally soft and porous, and furnishes an abundance of water of excellent quality at depths of 35 to 150 feet. A few wells in the northeast part of the La Harpe quadrangle, in Media, Ellison, and Raritan townships, and at a few other scattered localities, also obtain water from the Pottsville. However, the sandstones of this formation do not form continuous beds underlying the whole region, and this source cannot be depended upon everywhere.

The Burlington limestone is a very important source of water since it is known to underlie the whole region, and is water-bearing practically everywhere that it has been penetrated. The water occurs in porous zones in the limestone, but does not appear to come from any single bed or horizon that can be widely recognized. In the northwest part of the La Harpe quadrangle the limestone outcrops along the streams and lies at shallow depths under the surface of the uplands. Here drilled wells are common, and they obtain water of excellent quality from the limestone at depths of 35 to 250 feet. Over most of the region included in the two quadrangles, however, wells must be drilled to depths of 200 to 450 feet to obtain water from the Burlington limestone, and this is resorted to only where considerable quantities are needed, or where water seems to be absent in the shallower formations.

URBAN SUPPLIES

The water supply of the cities and towns comes from three sources, (1) shallow wells in the drift, (2) drilled wells in the Burlington limestone, and (3) deep wells in the St. Peter sandstone.

The towns of Good Hope, Greenbush, Sciota, Swan Creek, and Youngstown, all obtain their water from shallow wells in the drift. At Good Hope the wells are 25 to 50 feet deep, at Greenbush they are commonly 30 to 80 feet, at Sciota 20 to 80 feet, at Swan Creek 30 to 40 feet, and at Youngstown 20 to 80 feet.

The water supply at the villages of Decorra, Terre Haute, and Raritan, is obtained both from shallow wells in the drift and wells drilled into the Burlington limestone. Probably most of the water comes from the drift wells at depths of 20 to 80 feet.

The city water supply at La Harpe and Blandinsville comes from wells drilled into the Burlington limestone, although many private wells obtain water from the drift. The character of the shallow-well water from La Harpe is shown in Table 2.

Water from the drift or the shallower rock formations has generally been inadequate to supply the larger towns and cities, and consequently deep wells have been necessary. At Bushnell, Roseville, and Stronghurst, the city water supply comes from the St. Peter sandstone. At Bushnell two city wells obtain an ample supply of water at depths of 1,351 and 1,355 feet. This water, although hard, is fairly satisfactory for all purposes. Its character is shown by the analysis in Table 2. Many families obtain drinking water from shallow wells in the drift, and an analysis of such a water from Bushnell is also shown in the table.

At Roseville the city supply is obtained from the St. Peter sandstone at a depth of 1,260 feet. The water is similar to that at Bushnell and is satisfactory for most purposes. Two analyses of this water are given in Table 2.

At Stronghurst ample water is secured at a depth of only 1,009 feet, in the St. Peter sandstone. Another deep well in this city, owned by Dr.

TABLE 2.—*Mineral analyses of water from wells*

County	Fulton	Hancock	Henderson	Henderson
Town	Bushnell	La Harpe	Stronghurst	Stronghurst (City Supply)
Owner	T. E. Harris	City	Dr. Harter	City
Depth of well.....feet	920	60	1600	1009
Depth of casing.....feet	673	......	1056	......
Date sample was collected	Feb. 16, 1913	May 14, 1914	Nov. 23, 1908	July 3, 1908

Determinations mad

Potassium	5.9	3.0	17.7	......
Sodium	611.7	21.4	320.0	543.8
Ammonium	1.6	.8	1.0	2.5
Magnesium	38.9	36.6	51.0	110.6
Calcium	136.9	109.2	91.5	263.1
Iron	.2	10.0	2.2	4.
Alumina	8.7	8.2	10.2	.1
Nitrate	.000	.9	1.6	.5
Chlorine	520.	16.0	236.0	259.4
Sulphate	774.7	27.0	675.0	1604.0
Silica	15.0	......	6.8	9.6
Manganese	......	......	......	0.0
Bases	......	......	2.2	......

Hypothetical combinations

Potassium nitrate	11.2	1.5	2.6	......
Potassium chloride	......	4.6	31.8	......
Sodium nitrate	......	......	......	42.6
Sodium chloride	849.3	22.8	365.0	428.1
Sodium sulphate	854.4	38.2	543.0	1122.5
Sodium carbonate	......	......	......	......
Ammonium sulphate	5.8	1.7	3.7	9.4
Ammonium carbonate	......	.8	......	......
Magnesium sulphate	192.2	......	252.0	545.7
Magnesium carbonate	......	126.8	......	......
Calcium sulphate	56.4	......	148.0	546.5
Calcium carbonate	299.5	272.6	119.0	239.1
Iron carbonate	0.4	20.7	2.3	8.0
Alumina	8.7	8.2	10.2	.3
Silica	15.0	18.8	6.8	9.6
Bases	......	1.2	2.2	2.0
Non-volatile	......	......	......	......
Total	2292.9	517.9	1486.6	2953.8

Hypothetical combinations

Potassium nitrate	.65	.09	.15	......
Potassium chloride	......	.27	1.85	......
Sodium nitrate	......	......	......	2.47
Sodium chloride	49.53	1.33	21.29	24.81
Sodium sulphate	49.83	2.23	31.67	65.39
Sodium carbonate	......	......	......	......
Ammonium sulphate	.33	.10	.22	.54
Ammonium carbonate	......	.05	......	......
Magnesium sulphate	11.20	......	14.70	31.62
Magnesium carbonate	......	7.40	......	......
Calcium sulphate	3.28	......	8.63	31.69
Calcium carbonate	17.46	15.90	6.94	13.85
Iron carbonate	0.02	1.21	.13	.46
Alumina	.50	.48	.59	.02
Silica	.87	1.10	.40	.56
Bases	......	.07	.13	.12
Non-volatile	......	......	......	......
Total	133.67	302.3	86.70	171.53

n the La Harpe and Good Hope quadrangles

McDonough Bushnell (Tap, Home Service Laundry) City 1350 450 or 900 April 8, 1918	McDonough Bushnell (Spring) J. M. Brant (Spring) ...... July 31, 1917	Fulton Bushnell (Spring) J. E. Harris (Spring) ...... Aug. 2, 1909	Warren Roseville (Well dug into coal mine) City 50 ...... July 3, 1918	Warren Roseville City 1350 500 July 3, 1918	Chemical formula
parts per million)					
56.5	1.	......	......	......	K
462.0	15.5	9.1	73.0	466.5	Na
1.0	......	.6	.1	1.7	NH_4
47.6	20.0	103.2	50.2	77.1	Mg
97.9	65.9	333.8	108.3	182.6	Ca
0.8	0.0	89.5	0.4	2.8	Fe
0.0	2.6	70.1	1.2	.85	Al_2O_3
1.5	8.8	1.0	13.3	1.2	NO_3
370.	7.	3.0	59.0	205.0	Cl
679.0	5.9	1530.4	267.3	1165.0	SO_4
5.5	......	49.5	19.6	8.0	SiO_2
0.0	......	......	0.1	0.0	Mn
......	......	......	......	......	Bases
parts per million)					
2.4	2.6	......	......	......	KNO_3
9.0	......	......	......	......	KCl
......	9.9	1.4	18.2	1.7	$NaNO_3$
526.8	11.6	5.0	97.3	337.9	NaCl
776.3	8.7	20.7	91.8	1026.0	Na_2SO_4
......	12.4	......	......	......	Na_2CO_3
......	......	2.2	0.4	6.0	$(NH_4)_2SO_4$
......	......	......	......	......	$(NH_4)_2CO_3$
182.9	......	510.2	248.4	381.8	$MgSO_4$
37.7	69.3	......	......	......	$MgCO_3$
......	......	1132.9	9.3	229.7	$CaSO_4$
243.6	164.5	......	263.2	287.0	$CaCO_3$
1.7	......	......	0.8	5.8	$FeCO_3$
......	2.6	15.2	2.2	1.6	Al_2O_3
5.5	18.3	49.5	19.6	8.0	SiO_2
......	.3	3.0	......	......	Bases
......	......	......	2.8	7.2	Non-volatile
1785.9	300.2	2167.4	754.2	2292.7	Total
(grains per U. S. gallon)					
0.14	.15	......	......	......	KNO_3
0.53	......	......	......	......	KCl
......	.58	.08	1.06	.10	$NaNO_3$
30.73	.68	.29	5.67	19.70	NaCl
45.28	.51	1.21	5.35	59.85	Na_2SO_4
......	.72	......	......	......	Na_2CO_3
......	......	.13	.02	.35	$(NH_4)_2SO_4$
......	......	......	......	......	$(NH_4)_2CO_3$
10.67	......	29.75	14.49	22.27	$MgSO_4$
2.20	4.04	......	......	......	$MgCO_3$
......	......	66.08	.54	13.40	$CaSO_4$
14.21	9.60	......	15.35	16.74	$CaCO_3$
0.10	......	......	.05	.34	$FeCO_3$
......	.15	.89	.12	.09	Al_2O_3
0.32	1.07	2.89	1.14	.47	SiO_2
......	.02	.17	......	......	Bases
......	......	......	.16	.42	Non-volatile
104.18	17.52	126.40	43.96	133.73	Total

Harter, was drilled to a depth of 1,601 feet into what is probably the "Potsdam" sandstone. No analysis of the water from the city well is available, but that from the Harter well is shown in Table 2.

On the whole, the St. Peter sandstone offers ample resources of potable water for all needs that are likely to arise. A well drilled at almost any point in the region will penetrate this horizon at a depth of 1,000 to 1,350 feet, and in the absence of a shallower source of water, the St. Peter can always be depended upon.

Soils

The soils of the Good Hope and La Harpe quadrangles constitute the most important source of wealth in the region. The types found in the area may be classified as upland prairie soils, upland timber soils, and bottom land or flood plain soils. The upland prairie soils are present over all of the level or gently rolling interstream areas, which include nearly half of the surface of the quadrangles. In the more level places these soils are usually rich in organic matter, dark in color, and have been developed in the loess under conditions of poor drainage and moist temperate climate. Before the country was settled the roots of the prairie grasses and other plants that grew on the level uplands were protected from complete decay by the lack of perfect aeration, and the residual portions of this incompletely decomposed vegetable matter were permitted to accumulate and now form the humus of the black clay loam of the prairie soils.

Where the surface of the interstream areas was somewhat better drained and erosion a little more active so that during soil formation some of the upper part was being washed away, brown silt loam soils were formed. These soils contain less humus than the black clay loam, are browner in color and consist of about 10 per cent or more of clay, 8 to 20 per cent of rather fine sand, and 3 to 5 per cent of organic matter.

The upland timber soils are found chiefly over the slopes bordering the streams, which were covered with forests before the region was settled. These soils are commonly yellow to gray, and contain much less organic matter than the soils of the upland prairies, because the roots of the plants, and the leaves and other vegetal accumulations on the surface have almost completely decayed or been leached and eroded from the slopes, leaving scant residual organic matter in the soil. At present there are no large forested areas, and the timber is restricted to the steeper parts of the slopes that are not suitable for cultivation, or the small wood lots. Formerly, however, the forests covered almost all of the slopes to the outer parts of the most of the valleys. The upland timber soil is chiefly yellow silt loam. This soil washes and gullies readily owing to its position on the slopes, and is much less productive than the types of soil previously mentioned.

The bottom land or flood plain soils have been derived from material washed from the uplands in this or neighboring regions, and deposited by the streams as alluvium during times of overflow. These are more varied in composition than the other types of soils. Where they lie within reach of high water a thin film of sediment is deposited over them during every flood, and such accessions of new material, tend to preserve fertility. These are brown loam soils commonly containing sufficient sand to make the texture loose, sufficient clay to prevent ready injury by drought, and sufficient humus to make them very fertile.

SUMMARY OF MINERAL RESOURCES

At present the principal economic product of the region is coal, of which large quantities are still available in the bed known as No. 2 coal. Slight indications of the presence of petroleum have been observed, but no commercial production has been obtained. Certain areas are pointed out which are worthy of testing, on the basis of rock structure. A number of sand and gravel deposits are pointed out, which are capable of furnishing considerable quantities of road metal and building sand. There is no production of clay and shale, but areas are indicated in which valuable pottery clay may be present, and which should be further prospected. There are no important resources of building stone, although small quantities are available for local use in foundation walls, bridge piers, well-curbing, flagging, and similar work. Localities are mentioned in which limestone is available for road metal, concrete material, and limestone for fertilizer, and for manufacture of lime. Valuable deposits of iron, lead, zinc, or other metals are not believed to be present although isolated specimens of metallic minerals have been found. Water resources are ample for all purposes. The fertile soils constitute the most important natural resource in the region, and the greatest source of wealth in the quadrangles.

GEOLOGY AND MINERAL RESOURCES OF THE MORRIS QUADRANGLE

By Harold E. Culver

OUTLINE

PAGE
Chapter I.—Introduction 99
  Position 99
  General relations 99
  Acknowledgments 99
Chapter II.—Topography 100
  Relief 100
  Drainage 101
  Culture 102
Chapter III.—Descriptive geology 103
  Cambrian system 103
  Ordovician system 106
    Lower Ordovician series 106
    Middle Ordovician series 107
      St. Peter sandstone 108
      Platteville limestone 111
      Galena dolomite 113
    Upper Ordovician series 120
      Maquoketa formation 120
  Pennsylvanian system 128
    Pottsville formation 133
      Correlation 134
    Carbondale formation 139
  Pleistocene system 147
    Pre-Wisconsin drift 147
    Wisconsin drift 148
      Bloomington deposits 148
        Lacustrine clays 148
      Marseilles deposits 149
      Minooka deposits 153
      Fluvial and lacustrine deposits 154
    Recent deposits 161
Chapter IV.—Structural geology 165
Chapter V.—Historical geology 169
  Cambrian period 169
  Ordovician period 169
  Pennsylvanian period 171
  Mesozoic and Cenozoic eras 173
    Pleistocene period 173
      Marseilles stage 174
      Minooka stage 177
        Lake Morris sub-stage 178
        Cryder Lake sub-stage 180
    Later history of Illinois valley 183

OUTLINE — Continued

PAGE
Chapter VI.—Economic geology . . . 185
  Coal . . . 185
    General relations . . . 185
    Pottsville coals . . . 186
    Carbondale coals . . . 186
      No. 2 coal . . . 186
        Physical character . . . 187
        Chemical composition . . . 187
      Coal beds above No. 2 . . . 191
    Coal mining . . . 192
  Clay and shale . . . 194
    Ordovician shale . . . 194
    Pennsylvanian shale . . . 194
    Pleistocene clay . . . 196
  Stone . . . 197
  Sand and gravel . . . 198
  Water . . . 199
  Soils . . . 201
  Oil . . . 203

ILLUSTRATIONS

PLATE

II. Surficial geology and rock outcrops of the Morris Quadrangle . . . In pocket
III. Economic, structural, and areal geology of the Morris Quadrangle . . . In pocket
IIIA. Map of Morris Basin showing major physiographic features . . . 176

FIGURE

12. Index map of Illinois, showing the location of the Morris Quadrangle . . . 98
13. The head of the Illinois from the west side of Minooka ridge . . . 100
14. Generalized columnar section of the rocks of the Morris Quadrangle . . . 104
15. Quarry in Galena dolomite at Central, Kendall County . . . 116
16. Profile and structure section across Morris Basin . . . 117
17. Underground relations in southwestern Saratoga Township, Grundy County . . . 119
18. Aux Sable Creek at Shurtliffe Bridge, Kendall County . . . 121
19. Structure section across Kankakee River, near Lorenzo . . . 126
20. Carbondale sandstone, showing characteristic thin bedding and resistant lenses . . . 129
21. Lenticular concretions in Pennsylvanian beds along Mazon River . . . 131
22. Typical sandy shale of the Carbondale formation . . . 132
23. Spherical concretion in sandstone on Aux Sable Creek . . . 136
24. Pennsylvanian beds in the clay pit at the west end of Goose Lake . . . 137
25. Exposures of Carbondale beds along Mazon River near Tieders Ford . . . 138
26. Typical exposures of Carbondale strata on Mazon River . . . 139
27. Waupecan sandstone and underlying beds on Waupecan Creek . . . 140
28. Exposure showing beds below Waupecan sandstone . . . 141
29. Fissile shale showing calcareous phase with cone-in-cone structure . . . 143
30. Uneven contact of Waupecan sandstone with underlying shales . . . 144
31. "Millstone" concretions of Waupecan sandstone . . . 145
32. Sketch of outcrop of lake clays showing overlying till . . . 149
33. Map of Morris Quadrangle showing contours on bed-rock surface . . . 151
34. Dune near east end of sand ridge . . . 155
35. Gravel pit in NE. ¼ sec. 33, Goose Lake Township . . . 156

ILLUSTRATIONS — Continued

FIGURE PAGE
36. View showing the topographic relation between the present Illinois floodplain and the earlier gravel deposits.......... 157
37. Terrace gravels over till along Nettle Creek in Saratoga Township.......... 160
38. Near view of terrace gravel showing relation to till.......... 161
39. Gravel deposit in sec. 21, Wauponsee Township.......... 181
40. Graphic sections of No. 2 seam, Morris Quadrangle.......... 190
41. Refuse dump of shale and impure coal from mine near Coal City.......... 192
42. Typical surface equipment of a local coal mine at Morris.......... 193
43. View of small strip pit northeast of Morris.......... 194

TABLES

3. Tabulated data on the St. Peter sandstone for Morris Quadrangle.......... 109
4. Tabulated data on the Platteville limestone.......... 112
5. Logs of wells near Lorenzo, Will County.......... 127
6. Proximate analyses of No. 2 coal from Morris Quadrangle.......... 188

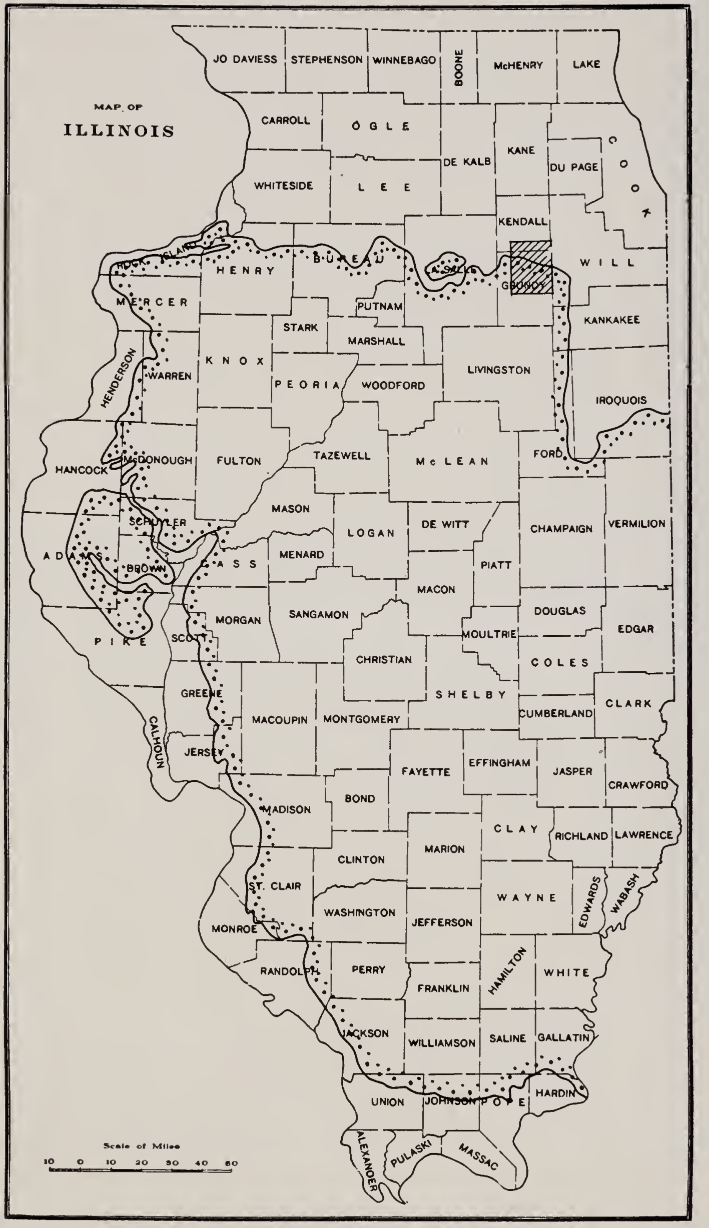

Fig. 12. Index map of Illinois, showing the location of the Morris Quadrangle. The stippled boundary outlines the Illinois coal field.

CHAPTER I—INTRODUCTION

Position

The region examined in this investigation lies along Illinois River in the vicinity of Morris (fig. 12). It comprises approximately half of Grundy County and a three-mile strip nearly across the southern part of Kendall County. The area has a width of 15 minutes of longitude, lying between meridians 88°15′ and 88°30′ west longitude, and a length of 15 minutes of latitude, lying between parallels 41°15′ and 41°30′ north latitude. The quadrangle includes 224.41 square miles within its boundaries, which disregard section, township, and county lines, being drawn in accordance with a plan for the systematic mapping of all the land in the United States.

General Relations

While at present primarily of importance for its agriculture, this region is one that will be benefited by the proposed Lakes-to-Gulf waterway, which, in addition to its stimulating effect upon farming, may make possible a greater development of its other industries. In earlier days before the utilization of the thick coal beds in the southern part of the State, coal mining was an important industry within the Morris quadrangle, although in 1920 there is but one shipping mine in operation.

Geologically the quadrangle is of interest because it includes a portion of the present boundary of the Eastern Interior Coal Basin, which comprises the coal lands of all of Illinois, Indiana, and western Kentucky. Within the "Coal Measures" here exposed are found the famous fossil beds of Mazon River, from which collections of almost perfectly preserved remains of plants and animals have been taken to many parts of the world. In addition, the Pleistocene or Glacial history of the region is of special interest since this portion of the valley of Illinois River was the site of an interesting series of drainage changes which were closely related to the development of glacial Lake Chicago and its outlet river.

Acknowledgments

In the gathering of data for this investigation the writer has enjoyed the courteous coöperation of a large number of people living within the quadrangle. He is especially indebted to the well drillers of the region for well logs, and to the mine operators for underground data.

Bulletin 10 of the Coöperative Mining Investigations[1] has been very helpful and has been freely drawn upon, as have some of the unpublished data gathered by former members of the Survey staff.

---

[1] Cady, G. H., Coal resources of District I: Ill. Coal Mining Investigations Bull. 10, 1915.

Credit is due Mr. Frank Collins Baker, who kindly determined the Pleistocene fossils, and offered suggestions as to the correlation of the enclosing deposits.

The writer wishes to express his appreciation of help given by the several members of the Survey staff, particularly Professor T. E. Savage, who determined the Paleozoic fossils, and Professor Morris M. Leighton with whom the Pleistocene study was initiated, and who has given the benefit of his experience in glacial investigations in this region, both by field assistance and by criticism of the Pleistocene chapters.

TOPOGRAPHY

The quadrangle includes the central part of the so-called Morris Basin. To the traveler the basin-like shape is not readily apparent because of its extreme shallowness, but is evident from the topographic map, and is emphasized by the arrangement of stream courses.

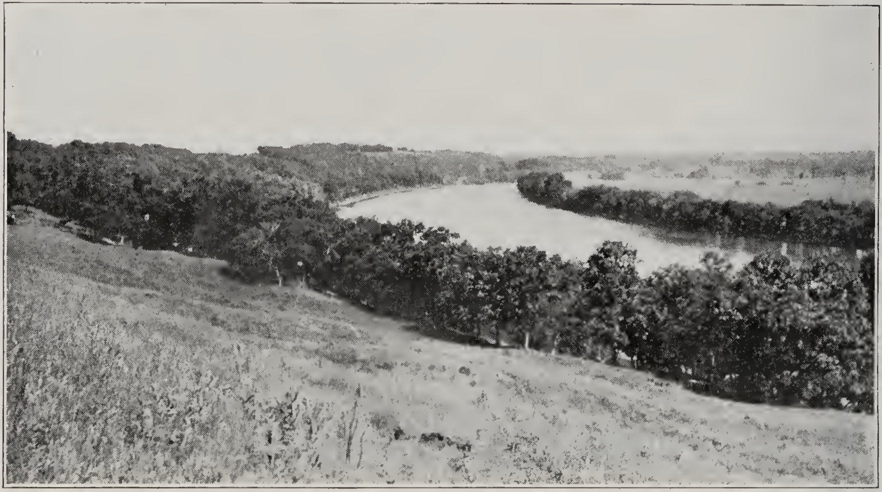

Fig. 13. The head of the Illinois from the west side of Minooka Ridge. The Desplaines is seen in the middle distance, with the Kankakee coming in from the south

Relief

The relief of the region as a whole is slight, there being less than 200 feet of difference between the highest and lowest points in the quadrangle. The greatest local relief is found at Dresden Heights, where the Illinois has cut a sharp bank 120 feet high in the glacial deposits of Minooka Ridge (fig. 13). The other features of pronounced relief are a short ridge in section 13 of Saratoga Township, the cemetery ridge west of Morris, and the sharply incised valleys of some of the streams in the southwest part of the quadrangle. Elsewhere the topography is of monotonous smoothness, the greater part of the area lying between 540 and 620 feet above sea level.

Notwithstanding this notable lack of relief, certain topographic features of the region are not without interest. For example, Ridge Road, leading northeast from Morris, runs along the upper edge of a prominent embankment, a topographic form obviously unrelated to the flat adjoining on the north. Similarly, the irregular depression of Goose Lake, the flat knolls to the north, and the collection of dunes known as Sand Ridge to the south are features suggestive of interesting relations.

It is evident to the careful observer that the topography of pre-glacial time has been almost obliterated by the work of later agents. Furthermore, it becomes apparent upon inspection of the region that the general smoothness is largely due to the work of ice, while the relation of the local relief features to the valley of the Illinois strongly suggests their origin in later stream action.

DRAINAGE

The master stream of the quadrangle is the Illinois, which heads within half a mile of the eastern boundary of the quadrangle at the junction of the Des Plaines and Kankakee rivers. The latter stream has a northerly course above that point and enters the quadrangle about two miles to the south near the point where it is crossed by the County Line Bridge.

The Illinois flows a little south of west at a velocity which varies from ½ to 3 miles an hour. From data gathered at the Federal gaging station at Elgin, Joliet, and Eastern Railway bridge about seven miles east of Morris,[2] the variation in measured volume amounts to 57,000 second feet, the extremes of observed flow being 7,000 and 64,000 second feet. With these changes, the water level fluctuates as much as 25 feet, the lowest recorded stage being 486 feet and the highest 511 feet above sea level. The flood plain shows great irregularity of outline but has an average width of about a mile. Numerous sloughs and lakes on the flood plain indicate relatively recent changes in the channel. Another feature worthy of notice is the abundance of elongate low-water islands of silt which characterize this portion of the Illinois as a depositing stream. By way of contrast, it is of interest to note that the Kankakee in its lower course is eroding its channel in resistant sandstone and limestone beds. In lesser degree this is characteristic of the Des Plaines also.

No tributaries of consequence enter the Des Plaines or the Kankakee within the quadrangle. The Illinois, however, has four prominent tributaries and several small ones. The two largest, Mazon River on the south and Aux Sable Creek on the north, drain more than three-quarters of the area. From the northwest comes Nettle Creek, a stream of two branches but no well developed tributary system. From the southwest flow Waupecan Creek and Bills Run, the latter of recent development without tributaries or branches, the former comparable in character with Nettle Creek on the north.

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[2] Water Resources of Illinois: Rivers and Lakes Commission, p. 34, 1914.

Inspection of the topographic map of the region suggests plainly a relation between the courses of the streams and the early history of Morris Basin. In the case of every stream draining the western half of the quadrangle the course shows a more or less distinct difference in trend in the upper and lower portions. This change in trend occurs at about the level of the earliest lake of which we have record in this depression.

The arrangement of stream courses has been referred to as emphasizing the shape of the Morris Basin. This type of drainage, characterized by the control of stream courses by the original slope of the land surface is known as *consequent,* and marks this as a region just starting on a cycle of erosion.

Culture

This district exhibits rural settlement rather than urban. Morris, county seat of Grundy, has a population of about 5,000; Coal City, including the old mining villages of Eileen, Carbon Hill, and Diamond, has approximately 3,000 inhabitants. Lisbon and Minooka have a few hundred each.

Nearly all the land is under cultivation, aside from the small undrained areas along the Illinois and the forested tracts. The woodlands are restricted to stream courses and sand areas, and, as shown by the topographic survey of 1915, comprise less than five per cent of the total area of the quadrangle. That portion of Grundy County included in the quadrangle has less than ten square miles of wooded land, while the Kendall County part has less than one square mile. The soil is for the most part fertile, and good crops are the rule. The production of certain areas has been increased by the addition of limestone and phosphate.

The region is well supplied with roadways, which follow the section lines in the main. Along the Illinois valley, however, the roads are parallel to its trend. There are many miles of hard surfaced roads, so that during most of the year a large part of the district is accessible by automobile. The mileage of paved road is being greatly increased at present with the completion of the Chicago-Illinois Valley highway and other main thoroughfares.

Adequate rail service is furnished by the lines between Chicago and the southwest. The main line of the Chicago, Rock Island and Pacific Railroad passes through Morris and Minooka, that of the Atchison, Topeka and Santa Fe Railway passes through Coal City, while a branch of the Cleveland, Cincinnati, Chicago and St. Louis Railroad crosses the extreme southwestern part through Wauponsee. The eastern part of the quadrangle is also served by the Elgin, Joliet and Eastern Railway. Additional service is provided by two electric lines, the Chicago, Ottawa and Peoria Railway, and the Illinois Valley and Fox River Union.

CHAPTER III—DESCRIPTIVE GEOLOGY

Solid rock of sedimentary origin underlies the loose surficial material in all parts of the quadrangle at depths ranging from a few inches to more than 120 feet. In the valleys of the larger streams, and rarely elsewhere, are scattered exposures of limestone, shale, or sandstone, which, as shown by drilling operations, are continuous under wide areas to a depth of more than 2,000 feet. Numerous borings of not more than a few hundred feet have been made in search of water, coal, oil, or gas. There are also a few deeper wells, of which that on the farm of Mr. Abe Hoge, Sr., located in NW. ¼ NW. ¼ sec. 25, T. 34 N., R. 6 E., reaching 1,921 feet, is perhaps the deepest.

From the logs of these holes, together with field studies of the outcrops in this and adjoining quadrangles, the geologic column showing the sequence and thickness of the strata for this region has been constructed. The rocks belong to a group of strata known as the Paleozoic, which is conveniently subdivided into seven systems, two of which are known to outcrop in the Morris quadrangle, one other being known from drilling.

The generalized geologic section (fig. 14) is typical of the quadrangle, but not exactly duplicated in any one boring. The reason for dissimilarity in different borings will become clear upon inspection of the areal map (Pl. III). A well near Lisbon will enter bed rock of Middle Ordovician age, one near Minooka will start in Upper Ordovician strata, while one near Coal City will pass first through Pennsylvanian beds, then through Upper, Middle, and Lower Ordovician beds, and since the thickness of these formations varies from place to place, none of these wells will encounter a section exactly like that given above.

Cambrian System

The Cambrian System, which includes the oldest rocks encountered in this region, lies more than 1,000 feet beneath the surface and has been reached by but few wells within the Morris quadrangle. Consequently it is little known and has no economic importance since it furnishes only water, which, though abundant, is of an inferior grade. At least two wells have been drilled into the Cambrian, the first in 1875, on section 25, Nettle Creek Township (T. 34 N., R. 6 E.), the Hoge well mentioned earlier, and the second in 1886 in the village of Minooka. No record of the latter is available, but that of the former makes possible certain conclusions regarding these deeply buried strata. The Hoge well encountered beds believed to be of Cambrian age at 1,200 feet and was continued for about 700 feet more. The complete log, with geologic interpretations, is given below. In both

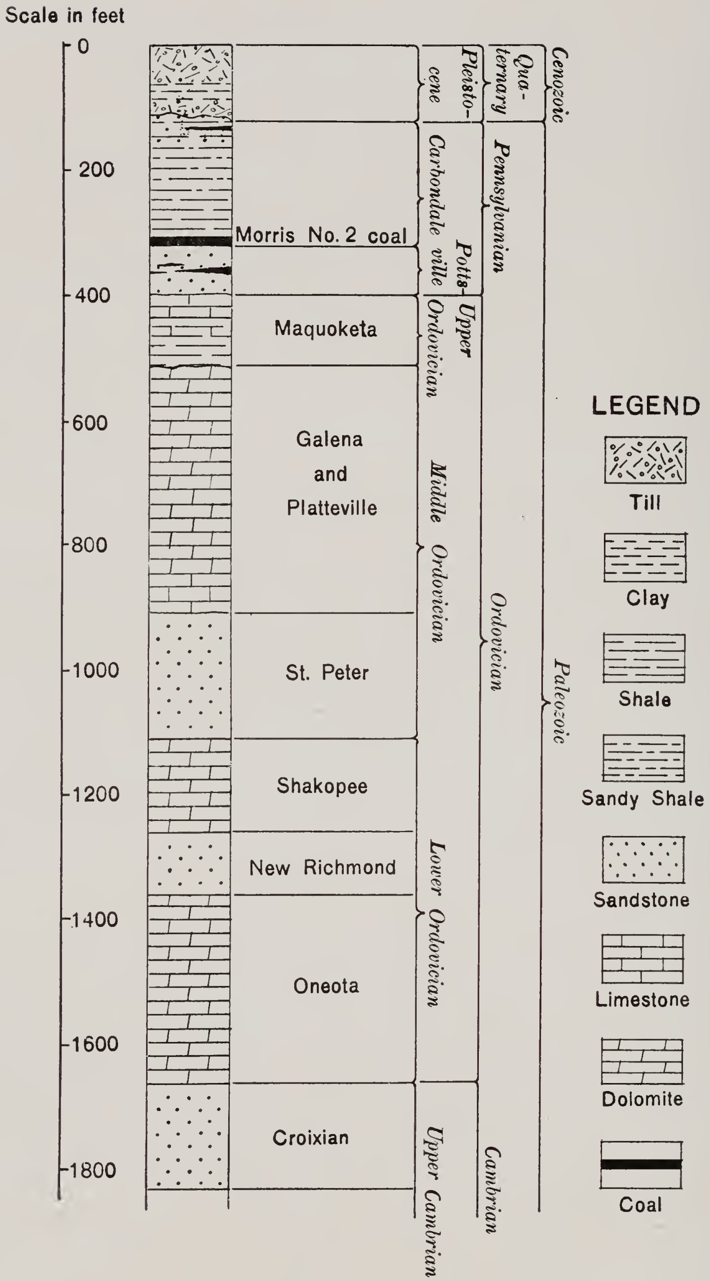

Fig. 14 Generalized columnar section of the rocks of the Morris Quadrangle

wells an abundant flow of water under high pressure was obtained, but that of the first well ceased after many years, probably on account of clogging of the well by caving matter.

Log[a] of an artesian well on the farm of Abe Hoge, NW. ¼ NW. ¼ sec. 25, T. 34 N., R. 6 E.

(Well drilled in 1875)

Description of strata	Thickness *Feet*	Depth *Feet*
Pleistocene and Recent		
Soil	50	50
Pennsylvanian		
Soapstone	8	58
Sandstone; soapstone	70	128
Ordovician		
Galena-Platteville		
Limestone	200	328
Shale	2	330
St. Peter		
Sandstone	200	530
"Cement" and shale	8	538
Sandstone	60	598
Prairie du Chien		
Limestone, white	185	783
Sandstone, white	93	876
Limestone, white	326	1202
Cambrian (?)		
Sandstone, red	166	1368
Limestone, gray	30	1398
Sandstone	317	1715
Limestone, gray	43	1758
Sandstone	163.5	1921.5

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[a] Log kindly furnished by Mr. Abe Hoge, Sr., of Morris.

The Cambrian system has been penetrated east of the quadrangle near Minooka, west of the quadrangle near Marseilles, and at Streator. Comparison of these logs with those from Ottawa, Joliet, Lockport, Aurora, Batavia, and Argo, suggests that the Cambrian of the Morris region may be subdivided into three members, an upper sandstone about 200 feet thick, a middle member comprising shales and sandstones with thinner interbedded limestones about 300 feet thick, and a lower sandstone more than 200 feet thick.

The difficulty of recognizing the base of the overlying Lower Ordovician rocks introduces an element of uncertainty in the conclusions regarding the Cambrian. However, the data from the Hoge boring accord well with the succession in other parts of Illinois, as well as generally throughout the Upper Mississippi basin. The name "Potsdam," formerly applied to this whole series of beds and still in common use, should be dropped, and Croixan substituted.

On the basis of the above correlation, the Cambrian has a general southeasterly dip of about 14 feet to the mile.

Ordovician System

Rocks of Ordovician age underlie all of the quadrangle. North of the "Coal Measures" area all outcropping beds belong to this system, which elsewhere is found below the Pennsylvanian. The same general relations obtain west of the quadrangle as far as the La Salle anticline. To the east, however, these strata pass beneath Silurian beds which outcrop prominently near Joliet.

The system is subdivided into three series: the Lower Ordovician, comprising the Prairie du Chien; the Middle Ordovician, including the St. Peter sandstone, the Platteville limestone, and the Galena dolomite; and the Upper Ordovician, here represented by the Maquoketa formation. The greatest measured thickness of Ordovician in the Morris quadrangle is 1,212 feet at Coal City, but since the full thickness of Maquoketa is not there present, and since the Cambrian rocks were not penetrated, the maximum thickness is probably between 1,300 and 1,400 feet.

LOWER ORDOVICIAN SERIES

The Lower Ordovician series, formerly known as the Lower Magnesian[3] and later renamed the Prairie du Chien[4], comprises three formations, to which in ascending order, the names Oneota, New Richmond, and Shakopee have been given. With the exception of the uppermost beds of the series, these strata are but little better known than those of Cambrian age, since they are seldom reached by the drill. There are only four available records from the Morris quadrangle although there are as many more from contiguous areas. Comparison of these logs shows the presence in this area of representatives of the three major divisions of the group as listed above.

The lowest formation, the Oneota, is usually logged as white limestone, although it is dolomite. It is 326 feet thick in the Hoge well and more than 346 feet at Coal City where it is reported to include more than 150 feet of sandstone in the lower middle portion.

The next formation above is the New Richmond sandstone. Drill cuttings of this rock show it to be in most places clean white standstone similar to the well-known St. Peter formation with which it has been confused not infrequently in drilling operations. It is separated from the St. Peter, however, by more than 100 feet of dolomite, and hence can be distinguished usually by position. Careful comparison of the sand grains will also in most cases make the distinction possible as the grains of the New Richmond are somewhat larger. Although in the records for this quadrangle this is a pure sandstone formation, the predominance of limestone recorded in the log of the Peddicord well north of Marseilles suggests the probability that interbedded limestones exist in the New Richmond formation in places. This accords with its character in the vicinity of La Salle.[5] The formation is 113 feet thick at Coal City, and 93 feet in the Hoge well.

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[3] Owen, D. D., Ex. Doc. 239, 26th Cong. 1st Sess., p. 17, 1840.

[4] Grant, U. S., and Burchard, E. F., U. S. Geol. Survey Geol. Atlas, Lancaster-Mineral Point folio (No 145), 1907.

The uppermost formation of the Prairie du Chien series outcrops in various parts of the State, and hence is better known than the underlying strata. It is dolomite of light color, usually gray or buff, mainly fine grained but showing coarse granular texture and marked porosity in places. This coarse phase together with the thin interbedded sandstones, account for the formation being sometimes incorrectly reported in drill logs as sandstone.

In the Hoge well it is recorded as white limestone, 185 feet thick. The Morris city well shows it to be light-gray dolomite, rather dense in texture, thickness not known. Four miles to the southeast a well on the John Holderman farm records 27 feet in limestone belonging to this formation, and at Coal City the total thickness of this stratum, described as sandy limestone, is 125 feet.

Just east of Coal City, at Braidwood, it is reported as a formation composed of white limestone and gray shale which was penetrated for a depth of 45 feet. More clastic material, both shale and sandstone, appear in this zone as it is traced northeastward, as much as 50 feet of shale appearing at the top in wells near Joliet.

MIDDLE ORDOVICIAN SERIES

This series, like the foregoing, has three formations which underlie most if not all of the Morris quadrangle. The lowest formation, the well-known St. Peter sandstone, is recognized readily by drillers and serves as a datum plane from which reasonably accurate stratigraphic measurements may be made on well logs. The other two formations, the Platteville limestone and the Galena dolomite, are indistinguishable in this region since only the latter outcrops and no criteria for the recognition of the contact of the two in drill logs have been developed. This portion of the series is therefore referred to as the Galena-Platteville formation in this report. The measured thickness for this series in the quadrangle ranges from 470 feet in the Hoge well to 581 feet in the Morris city well No. 2. Figures for the latter may be slightly in error but their approximate accuracy is indicated by a recorded thickness of 550 feet in the Coal City well.

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[5] Cady, G. H., Geology and mineral resources of the Hennepin and La Salle quadrangles: Ill. State Geol. Survey Bull. 37, p. 35, 1919.

ST. PETER SANDSTONE

Outcrops of this formation west of the quadrangle in La Salle County show it to be sandstone of unusual purity. It is composed of well-rounded quartz grains which are in places but slightly cemented and in places firmly held together. Drill cuttings are nearly always composed of loose grains. While the upper and lower portions are stained to a greater or less degree and hence appear yellow or brown, black or blue, the formation as a whole is almost snow-white. This, taken with the rather uniformly small size of grain, serves as a means of ready identification in drilling. The formation is nearly devoid of fossils so that this common means of recognition of beds is not available.

The St. Peter sandstone is encountered in the Morris quadrangle at depths ranging from less than 125 feet to about 600 feet. This wide range is due in part to the inequality in the amount of cover of surficial materials, and in part to difference in altitude of the surface of the sandstone. This difference in altitude is itself due largely to the southeast dip of the formation, but probably in part also to erosional irregularities in the surface of the rock.

A table is appended giving these data and also the elevation of the surface above sea level, the thickness where known, and the character of the strata above and below.

The thickness of the formation is about 200 feet, but considerable variation is shown in logs. From the few data at hand it is not clear that the variations are due to a uniform or widespread thickening and thinning of the bed, since the fortuitous disposition of the wells may show variations due merely to erosional irregularities of the upper surface in conjunction with similar irregularities of the upper surface of the Shakopee dolomite below. If the last two factors are compensating, the Coal City and Holderman wells indicate that the formation is thinner in the southeast part of the quadrangle. An extension of this area to the northeast would include the thin part at the Minooka "oil well," on DuPage River, where only 110 feet of St. Peter was recorded. That this is a belt rather than a wide area of thinner sandstone is indicated by a thickness of more than 200 feet at Braidwood, farther to the southeast. In this connection it is of interest to note that in the area of outcrop of the St. Peter formation west of the quadrangle, there is no evidence of erosional irregularities in the surface of the formation of more than 40 or 50 feet.[6]

Since all data on the St. Peter formation in the Morris area are from well logs, but little can be said of the contact of this formation with those above or below. In a few instances drillers have noted peculiarities at the upper surface which are of interest.

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[6] Cady, G. H., Structure of the La Salle anticline: Ill. State Geol. Survey Bull. 36, p. 106, 1920.

TABLE 3.—*Tabulated well data on St. Peter sandstone for Morris Quadrangle.*

Location		Depth	Elevation	Thickness	Contact with adjacent beds	
Township	Sec.				Above	Below
KENDALL COUNTY						
Big Grove	24	123	547	......	3 ft. flint	......
(T. 35 N., R. 5 E.)	24	200	480+	......	......	......
	27	181	544	......	181 ft. drift	......
La Salle (T. 34 N., R. 5 E.)	32	360	360	195	25 ft. limestone	limestone
GRUNDY COUNTY						
Nettle Creek	3	170	450	......	"common surface"	......
(T. 34 N., R. 6 E.)	5	176	489	......	47 ft. Pennsylvanian	......
	10	180	425	......	10 ft. limestone	......
	13	205	395	......	91 ft. limestone	......
	13	255−	330+	......	185 ft. limestone	......
	14	198	407	......	40 ft. Platteville + 49 ft. Galena	......
	15	190	410	......	76 ft. limestone	......
	20	214	411	......	44 ft. limestone	......
	23	255	330	......	139 ft. limestone	......
	23	238	347	......	53 ft. soapstone + 74 ft. limestone (Galena)	......
	23	240	345	......	125 ft. limestone	......
	25	330	260	268	2 ft. clay; 8 ft. shale 60 ft. from base	white limestone
	26	256	339	......	116 ft. limestone	......
	32	268	350+	......	?	?
Saratoga	12	350	210	......	......	......
(T. 34 N., R. 7 E.)	18	250	330	......	140 ft. limestone with clay pockets at base.	......
	19	244	321	......	154 ft. limestone	......
	20	100	368	......	......	(of doubtful accuracy)
	24	380	155	......	limestone	......
	30	281	279	......	168 ft. limestone	......
	30	316	244	......	limestone	......
	30	233	327	......	133 ft. limestone	......
	30	278	271	......	limestone	......
	31	287	263	......	limestone	......
	32	318	227	......	1 ft. black clay	......
	35	344	181	......	limestone	......

TABLE 3.—*Tabulated well data on St. Peter sandstone for Morris Quadrangle*—Continued.

Location		Depth	Elevation	Thickness	Contact with adjacent beds	
Township	Sec.				Above	Below
Aux Sable	9	322	263	......	limestone (?)..........	?
(T. 34 N., R. 8. E.)	10	549	50	......	90 ft. limestone.......	....
	30	263	262	......	limestone (?)..........	....
Erienna	3	290	305	......	80 ft. limestone.......	....
(T. 33 N., R. 6 E.)	4	294	316	......	limestone.............	....
	8	260	340	......	105 ft. limestone......	....
	10	296	284	......	limestone.............	?
	13	363−	137+	......	limestone.............	....
	15	443	47	......	?	?
	15	217	283	......	limestone.............	....
Norman	22	374	221	......	(?) 18 ft. clay (pocket?)	....
(T. 33 N., R. 6 E.)	22	400	200	......	limestone.............	....
	22	391	210	......	limestone.............	....
	27	409	196	......	"gumbo" over 1 ft. rock	....
Morris	4	317	203	......	?	....
(T. 33 N., R. 7 E.)	4	316	204	......	limestone.............	....
	4	315	205	......	limestone.............	....
	4	330	193	......	shaly limestone........	....
Goose Lake (T. 33 N., R. 7 E.)	12	600+	−50	......	?	....
Goose Lake (T. 33 N., R. 8 E.)	18	504	31	175	limestone.............	....
Mazon (T. 32 N., R. 7 E.)	10	554	16	......	?	....
Braceville (T. 32 N., R. 8 E.)	3?	600	−40	150	limestone.............	....
WILL COUNTY						
Channahon.......... (T. 34 N., R. 9 E.)	6	440	?	110	limestone.............	30 ft. gray shale
Reed (T. 32 N., R. 9 E.)	8	645	−75	210	limestone.............	limestone with green shale

Inspection of the preceding table shows clay, recorded variously as "black clay," "gumbo," "clay pocket," etc., in four wells so arranged as to suggest that their geographic relation has no significance. The three feet of flint from one well may be interpreted, in the absence of samples, as a silicified phase of the overlying Platteville limestone, or as an especially well cemented upper part of the St. Peter sandstone itself. In two cases, both a short distance west of the north end of the quadrangle, the covering is loose, surficial material indicating a removal of the overlying bed rock in that region.

In the logs of the six wells passing through the St. Peter sandstone none records any peculiarity at the sandstone-dolomite contact below.

Sufficient data are at hand to show with fair accuracy the contour of the upper surface of the formation, but the delineation of the lower surface can not be attempted. For a distance of 25 miles in a general east-west line, however, the decline of the upper surface eastward amounts to 435 feet, or 17.4 feet per mile. The lower surface slopes 450 feet in the same direction, or at the rate of 18 feet per mile. It appears therefore that the dip of the formation must be of approximately this amount. The maximum slope, however, appears to be to the southeast (see contours on Plate III), in which direction it amounts to more than 28 feet per mile. From the data cited above, this is probably near the true dip of the formation.

PLATTEVILLE LIMESTONE

Above the St. Peter sandstone over most if not all the Morris quadrangle lies the Platteville limestone. This formation is characteristically non-magnesian in contrast to the other calcareous members of the Ordovician and Silurian systems which are largely dolomitic. This member does not outcrop in the region, however, and its probable character here must be determined from exposure elsewhere. Because of its lithologic similarity to the overlying member of the Ordovician, the Galena dolomite, drillers do not usually distinguish the two formations. Examination of drill cuttings renders the identification of the Platteville possible in some instances. It is customary, on account of their similarity, to place the two formations together as the Platteville-Galena. In the records of four borings, from two of which samples of drill cuttings have been examined by members of the Survey, it is possible to reach tentative conclusions regarding the Platteville. These data are presented in tabular form below, and a generalized section of the Platteville[7] is appended for comparison.

Lithologically there is considerable similarity in these sections. In each case the Galena is represented by a considerable thickness of material of uniform character, while the lower portion of the record shows variation in composition in relatively short distances. This difference in character of

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[7] Grant, U. S., and Burchard, E. F., U. S. Geol. Survey Atlas, Lancaster-Mineral Point folio (No. 145), p. 4, 1907.

TABLE 4.—*Tabulated data on the Platteville limestone*

Formation	Sec. 14, T. 34 N., R. 6 E.		Sec. 4, T. 33 N., R. 7 E.		Sec. 28, T. 32 N., R. 7 E.		Sec. 25, T. 33 N., R. 9 E.	
	Strata	Thickness	Strata	Thickness	Strata	Thickness	Strata	Thickness
		Feet		*Feet*		*Feet*		*Feet*
Galena.........	solid limestone	49	dolomite......	130	hard limestone	216	limestone.....	242
Platteville......	brown seam..	3	?	30	soft limestone	60	shale.........	3
	solid limestone	21	limestone.....	5	....	....	limestone.....	25
	soft limestone.	1	?	50	hard limestone	12	dolomite......	35
	limestone with soft seam...	15	dolomite......	5	....	....	....	....
St. Peter.......	sandstone.....	20+	sandstone.....	200+	sandstone.....	87+	sandstone.....	165+

Generalized section of Platteville from southwestern Wisconsin

	Feet
Limestone, principally in thin beds, and shale	10—15
Thin-bedded, brittle, fine-grained limestone	15—25
Thick-bedded, magnesian limestone or dolomite	15—25
Blue shale, at some places sandy	1—5

material, indicating changed conditions of sedimentation, is suggestive of a difference in age, and the lower beds are tentatively assigned to the Platteville.

On this basis the Platteville formation in this region includes a limestone phase, possibly with some shale above and a dolomitic phase below. The basal sandy shale, which typically is sharply delimited by the overlying calcareous beds but grades into the St. Peter sandstone below, was apparently not distinguished by the drillers in the cases cited above. In some other instances, however, there is noted a blue shaly phase, commonly recorded as the "blue St. Peter," at the contact of St. Peter sandstone and the overlying beds. It is possible that this phase is present in most places, but is not recognizable in the drilling records.

As indicated in the discussion of the St. Peter sandstone, the data from this region are in harmony with the conception of an unconformity accompanied by erosional irregularities of surface between that formation and the Platteville. A similar relationship between the Platteville and the overlying Galena is suggested but not proved by the data from this region.

GALENA DOLOMITE

The top member of the Middle Ordovician is the oldest formation exposed in the Morris quadrangle. It is the dolomite which outcrops in several places north of the "Coal Measures" area. At no point is an extensive section exposed and the paucity of outcrops makes impossible the accurate correlation of such beds as do appear. The general character of the formation can be determined, but the relative amounts of the different kinds of beds can not. One of the most extensive outcrops is in the extreme northwest part of the quadrangle on the headwaters of Saratoga Creek, in sec. 36, T. 35 N., R. 6 E. Here, for a distance of about 400 yards on each side of the wagon bridge, the stream has cut a shallow channel in the resistant dolomite, which at this place has a thin cover of loose material.

The rock is finely crystalline to earthy in texture. Although probably gray when fresh, the exposures show a buff color, with pinkish tone in places. On more complete weathering the rock becomes a yellow-brown porous mass in which are irregularly shaped pockets containing small crystals of calcite. The presence of small stringers of calcite and of small areas (one-half a square inch in size) in which uniform orientation of cleavage planes obtains, indicates recrystallization subsequent to deposition.

Yellowish-white to white chert is not rare, being apparently confined to the bedding planes. The rock is thin-bedded, especially in the upper, more weathered portion, 4 inches being the maximum thickness observed. In the outcrop probably less than 15 feet of strata are exposed, although the uniform character of the beds makes this determination doubtful. Above the bridge the dolomite shows a low downstream dip for about 100 yards, but elsewhere is apparently quite flat. A shallow gully some rods to the east exposes about 6 feet of dolomite which there shows a southwest dip of about 1°. The very limited outcrop gives no suggestion as to the distance over which this structure is maintained. Jointing is prominent locally, the better developed planes trending N. 56° W. These have been the site of pronounced weathering in places, giving bands of yellow clay residue as much as 2 inches wide. The formation is here sparsely fossiliferous. A few crinoid segments, one flat-valved brachiopod, a mold of a straight cephalopod, and numerous fragments of the coral, *Columnaria officinalis,* are all that have been seen.

From lack of marked irregularity in the surface of the dolomite over the whole exposure, planation by glacial action is suggested. Although the exposure shows wear by streams rather than by ice, two small patches have smoothed and striated surfaces. On these two the grooves and striations trend uniformly S. 56° W.

An exposure of about equal stratigraphic thickness is found in the abandoned quarry on the north outskirts of Lisbon village. Here the following section is obtained:

Section of Galena dolomite in abandoned quarry near Lisbon

	Thickness	
	Ft.	*In.*
Soil, gray black	..	10
Clay, gray brown	1	2
Dolomite, well weathered, light yellow brown (crumbles easily, variable thickness)	3	6
Dolomite, cream gray, more regular bedding and jointing	5	6
Dolomite, probably same as above, but discolored from long submergence	3	0

Lithologically the rock is quite like that previously described. While much greater variation in texture and color is to be seen, it seems to be due to differences developed in weathering. No color or texture appears to be confined to any one bed or group of beds. Only slight traces of fossils were noted, mainly crinoid segments, although a loose fragment showed *Dalmanella testudinaria.* In this nearly circular quarry, about 60 feet in diameter, the beds are flat-lying.

Two and one-half miles east of this quarry, in section 21 of Lisbon Township, another opening in the Galena has been made. The operation of this quarry in 1920 exposed the following section:

Section measured in sec. 21, Lisbon Twp.

	Thickness *Feet*
Drift	1
Dolomite, weathered, buff (thickness 2-10 feet)	5
Dolomite, more slabby than above, buff	5
Dolomite, fresh, pinkish gray, finely crystalline	5

In the beds exposed there are no marked differences except those due to weathering. The pink tone is very faint in the fresh rock, which is distinctly gray. From it are derived by weathering various cream, buff, brown and green tints in great irregularity. The upper beds show the same weathering effects as were described for the Lisbon quarry, but here the depth to which the weathering has progressed is less uniform. Relatively fresh rock appears at the surface at the north end of the quarry, while at the south end an advanced stage of weathering has extended to a depth of 10 feet. In the fresher part the bedding planes are about 8 inches apart.

These beds show no sets of joints but instead are broken by a few irregularly disposed cracks, essentially vertical. The greater abundance of these in places is probably related to the variation in depth to which weathering has progressed. Clay seams filling these joints to a depth of 10 to 12 feet are common.

Careful examination reveals a few fossils. Without exception the calcium carbonate has been leached from the shells, leaving casts and molds. In this connection it is of interest to note the presence of crystals of calcite up to 2 inches in diameter in the rock, but not evidently filling cavities The fossils are listed below:

Fossils from the Galena dolomite collected in sec. 36, T. 35 N., R. 6 E.

Ambonychia sp. cf. affinia
Liospira sp. cf. vitruvia
Lophospira sp.
Murchisonia sp.
Receptaculites oweni
Rhynchotrema increbescens
Trochonema sp. undescribed cf. stroporallus

In the abandoned quarry at Central (fig. 15), a little more than a mile to the south, only the upper 5 feet can be examined. The rock dump, however, shows finely crystalline, pinkish-gray rock, weathering buff, with iron stains and considerable calcite, and also bluish-gray rock which has a distinctly pink tone in some places. The texture of the two is identical, being in part massive and in part finely crystalline. It is probable that the darker rock comes from the lower part of the quarry, which is reported to be 35 or 40 feet deep. In that case it is likely that the upper rock is merely the weathered equivalent of the lower. This relation is similar to that noted for the quarry to the north. One distinction between these exposures is the depth to which weathering has advanced. In the quarry to the north an advanced stage has been reached at a depth of 10 feet and all calcite of shells has been removed. Here relatively fresh rock appears at the surface on all sides and the fossils show no leaching. A related feature of difference is the fact that in the latter case the surface has been planed off by the ice, while in the former this is not evident.

The fossils include the following:

Fossils from the Galena dolomite in the old quarry at Central in sec. 28, T. 35 N., R. 7 E.

Eccyliopterus sp.
Leptaena rhomboidalis
Orthis plicatella
Refinesquina alternata
Trochonema (?) sp.
Zygospira recurvirostra

Other exposures of essentially the same type of rock are in a run three-quarters of a mile west of Central on the north line of section 32 and in an abandoned quarry 1½ miles east on the east line of section 34.

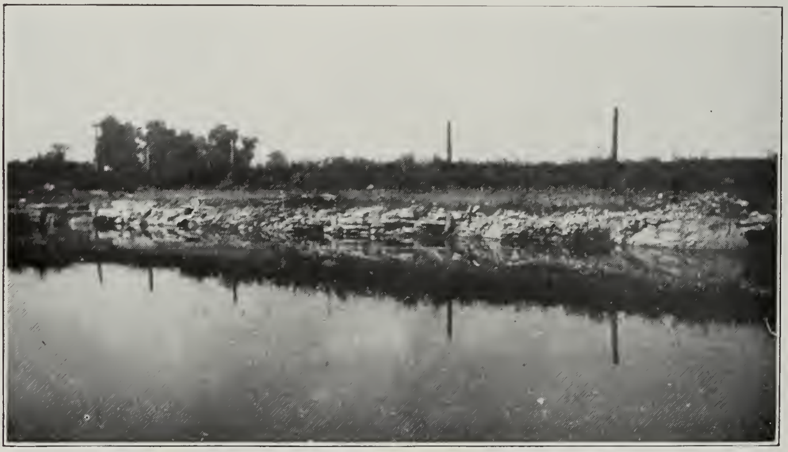

Fig. 15. Quarry in Galena dolomite at Central, Kendall County

But three other exposures of this formation have been noted in the Morris quadrangle. In section 24 of Saratoga Township (T. 34 N., R. 7 E.) there is an abandoned quarry south of Ridge Road. The rock here is of gray-brown color, fine to medium-fine crystalline texture, and contains considerable pyrite in small grains. On weathering, an irregular surface and a marked rusty spotting is developed. The beds are sparsely fossiliferous. About a mile to the northeast, in section 18 of Aux Sable Township (T. 34 N., R. 8 E.), Collins Run exposes Galena dolomite at the wagon bridge near the Walley School. Not more than two feet of beds are exposed and they show no distinguishing characteristics. The rock is gray, near tan on some surfaces, and has a faint pink tone in others. Weathering brings out the pink color and produces also a yellow-brown stain, which is pronounced along joint planes and in cavities. Some calcite is present,

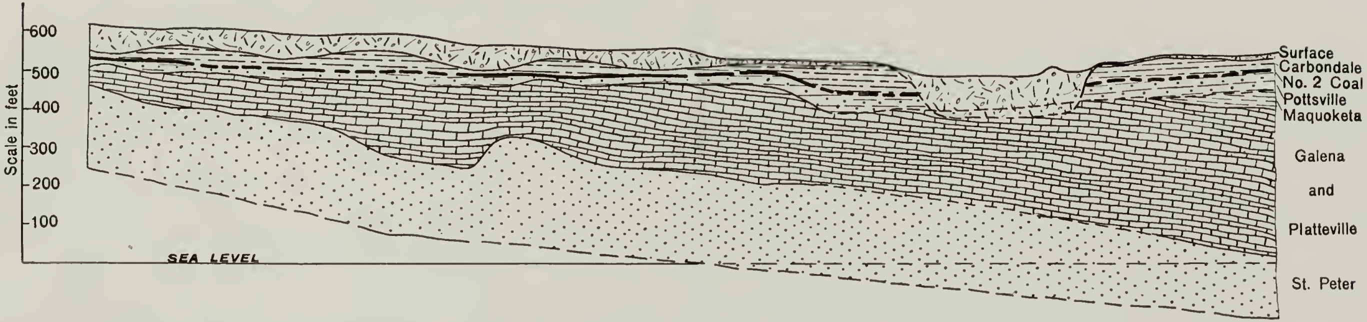

Fig. 16. Profile and structure section A—A′ (Plate III) across Morris Basin from sec. 24, Nettle Creek Twp., to sec. 20, Goose Lake Twp.

but not as much nor in as large masses as in the Central quarry beds. Fossils are neither rare nor abundant. Those gathered include:

Fossils from the Galena dolomite in sec. 18, T. 34 N., R. 8 E.

Bellerophon species
Illaenus americanus (?)
Lophospira sp.
Orthoceras sp.
Rhynchotrema increbescens

The most southeastern outcrop of the formation is in the bed of Aux Sable Creek in sec. 19, T. 34 N., R. 8 E., north of the Rock Island tracks. This comprises several isolated patches of rock smoothed by glacial action but with that surface largely modified by later stream action. The fresh rock is not exposed but seems to be gray dolomitic limestone, finely crystalline to dense in texture. It has a gray to dirty white surface color and weathers to buff below. Pyrite is rather common throughout the beds, giving rise to a "pockety" surface through weathering and stream wear. From these outcrops there appear to be two phases of the formation represented. A lower, more pyritiferous part, and an upper part comprising more fossiliferous beds. There is no indication from these outcrops of the area over which these phases are distinct. The only fossils noted were *Rafinesquina alternata* and *Delmanella testudinaria.*

The beds at this place appear to have a slight dip to the northwest.

Logs of wells in the Morris area show a much wider distribution of the Galena-Platteville formation than is indicated by the outcrops. In fact, every section in the quadrangle shows some portion of this formation, although covered by other strata in most places. Its probable presence beneath valley fill in the Illinois valley will be noted in connection with the Pennsylvanian (fig. 16). The only additional lithologic data obtained from a study of logs have reference to certain features which probably are common throughout the formation but of local rather than widespread development. These include such variations from the normal dolomite as soft bands from a few inches to several feet in thickness; chert bands; thin sandy phases; and cavities or pockets commonly lined or filled with clay. Some of these cavities are several feet in diameter and probably are the result of solution. Pyrite is common in the formation but has no apparent restriction to any zone.

As a result of the combination of several factors, the thickness of the Galena-Platteville formation ranges from 400 feet to less than 100 feet within the quadrangle. Sufficient data are not at hand to delineate the surface in detail, but an inspection of well logs brings out the relationship of the several factors to the known variation in thickness.

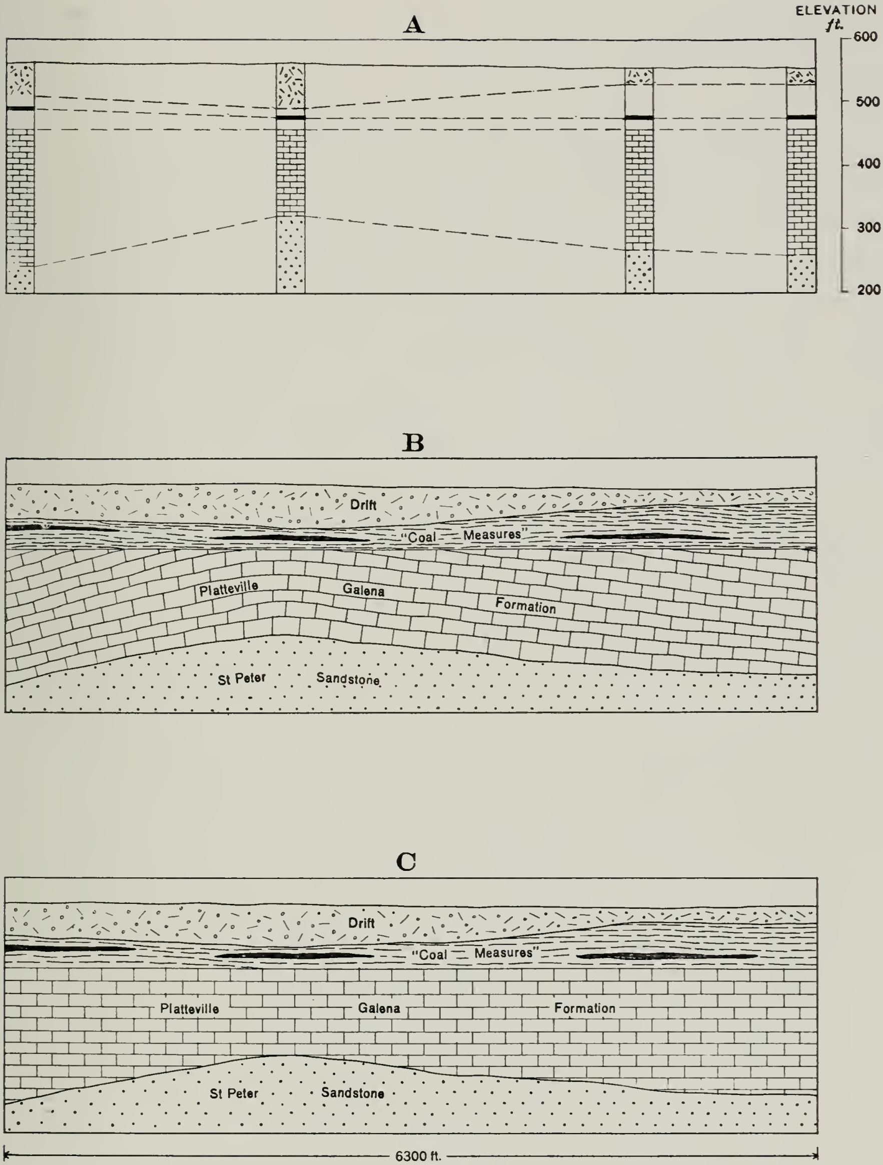

Fig. 17. Underground relations in southwestern Saratoga Township, Grundy County.

The thickest part is in the Coal City region, and from there northwestward the formation thins so that a short distance west of the limits of the quadrangle the underlying St. Peter is the uppermost bed rock. This variation, amounting to nearly 100 per cent of the total thickness, is due to plantation of the formation, which has a slight tilt to the southeast. Another variation, more pronounced because of the small area involved, is in the southwest part of Saratoga Township (T. 34 N., R. 7 E.). Here a group of wells shows thicknesses ranging from 216 down to 133 feet in one square mile (fig. 17A). Since the upper surface of the formation shows but 10 feet of relief in this area, the observed variation in thickness is caused by the unevenness of the lower surface. Consideration of the structure of the St. Peter formation over the quadrangle leads to the inference that this variation is the result of planation of the beds where upwarped (fig. 17B). By an alternative interpretation of these data the indicated relief of the sandstone surface suggests a measure for the difference in original thickness of the overlying calcareous series (fig. 17C).

There are also variations clearly due to unevenness of the upper surface. Thus in the city of Morris wells show a distinct rise of the surface of the dolomite northwest of the Illinois which corresponds only roughly to the increase in thickness in that direction.

One other factor, the effect of which can not be definitely stated, is that involving the Platteville formation as a unit. Too little is known of this formation to warrant other than very general deductions as to its thickness or the amount of erosion it suffered before the deposition of the overlying Galena. It is probable, however, that whatever relief was developed on its surface was compensated by a corresponding inequality in deposition of the Galena.

The absence of records showing the elevation of both the top and bottom of the Galena-Platteville, in an area where it has not obviously suffered erosion, precludes any inference as to the structure of this formation. It may therefore be assumed to have a structure similar to that of the underlying St. Peter sandstone.

UPPER ORDOVICIAN SERIES

In the Morris quadrangle, as elsewhere in Illinois, the Upper Ordovician series is represented by but one formation, the Maquoketa, which is considered to be of Richmond age.

MAQUOKETA FORMATION

Exposures of the beds of this formation are limited to the northeast part of the Morris area. One group of exposures is to be seen from the Grundy County line northward beyond the limits of the quadrangle, in the bed and low banks of Aux Sable Creek (fig. 18). Because of the low relief of the region and the nearly horizontal attitude of the beds, only a limited stratigraphic section can be measured in the whole distance.

Another group of exposures is in the vicinity of the head of Illinois River, including the southeast part of Aux Sable (T. 34 N., R. 8 E.) and the northeast part of Goose Lake (T. 34 N., R. 8 E.) townships. The outcrops, with one unimportant exception, are the tops of low rock knolls which here and there protrude through the thin cover of later deposits, so that but little knowledge can be added to the stratigraphy as determined from the Aux Sable Creek section.

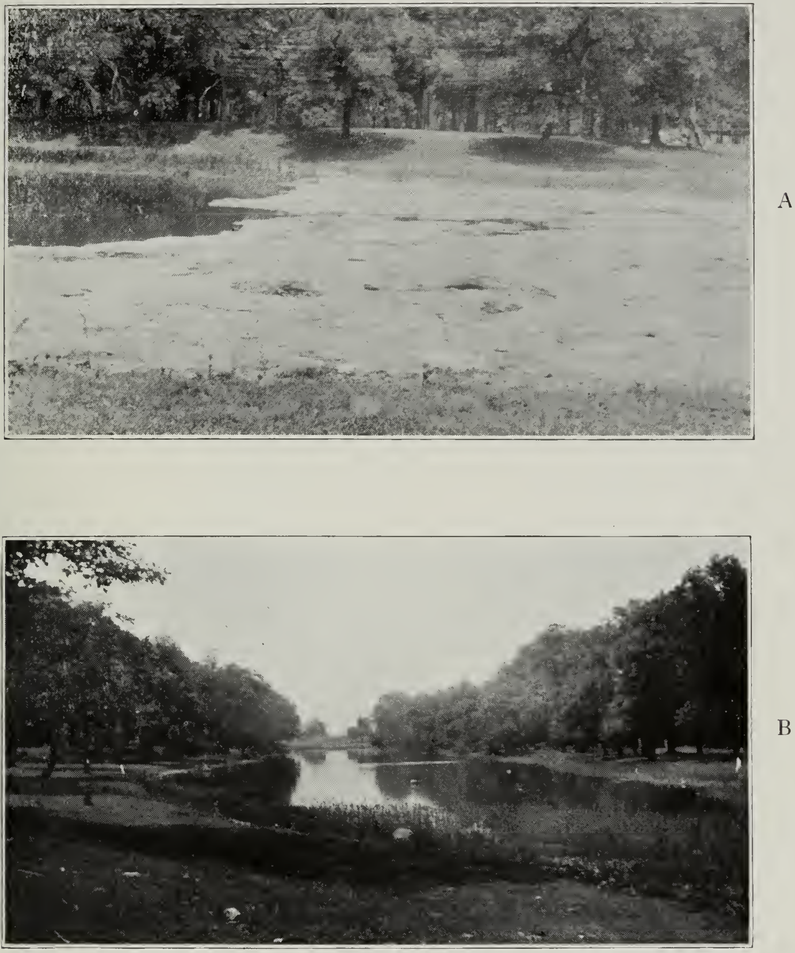

Fig. 18. Aux Sable Creek at Shurtliffe Bridge, Kendall County
A. Maquoketa limestone in bed of creek
B. Ponding of creek above outcrop shown in A

The exposed rocks include beds of calcareous shale and of impure as well as of relatively pure limestone. The shale is thin-bedded, mainly without grit, light to dark gray, and weathers to a flaky incoherent mass. Consequently it is seen only where protected by a capping ledge of limestone. The limestone shows considerable variety of texture from dense to coarse-grained. Medium-gray when fresh, it develops a buff to brown weathered surface which effectually conceals both textural and color distinctions between beds in most exposures.

Characteristically this formation contains an abundance of fossils, including crinoids, bryozoans, brachiopods and trilobites, but some strata are practically devoid of organic remains. This lack is especially noticeable in the shale phases.

All beds of this formation appearing along Aux Sable Creek within the quadrangle are represented in exposures in section 3 of Aux Sable Township (T. 34 N., R. 8 E.). A total of 17 feet of strata are exposed in the outcrop near the wagon bridge. The section follows:

Section of Maquoketa beds exposed along Aux Sable Creek

		Thicknes.	
		Ft.	*Ins*
14.	Limestone, coarse,[a] gray brown, no fossils, stylolitic	..	6
13.	Limestone, coarse, grayish brown, fossils common, beds 10 inches thick	2	6
12.	Limestone, medium coarse, gray, fossils less common than above	4	0
11.	Limestone, slightly finer than No. 12, tan, few fossils, slabby on weathering	1	6
10.	Limestone, medium fine, gray tan, fossils abundant, usually includes a 2-inch shaly layer about 1 foot above base	1	6
9.	Limestone, medium coarse, gray, fossils abundant on bedding planes	1	6
8.	Limestone, shaly, thin bedded, somewhat uneven but persistent	..	2
7.	Limestone, medium coarse and like No. 9	2	6
6.	Shale, calcareous, gray, soft, thin bedded, varies from 2 inches to	0	6
5.	Limestone, fine, nearly dense, pinkish gray, fossils abundant	0	3
4.	Shale, like No. 6	0	6
3.	Limestone, like No. 5	0	3
2.	Shale, like No. 6	0	9
	Concealed (possibly shale)	0	6
1.	Limestone, like No. 5 (base concealed)	0	3
		17	2

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[a] In field examination of sediments, the texture has been classified as follows: coarse, medium coarse medium fine, fine, and dense.

The beds of the above section are readily grouped on a lithologic basis into two divisions, an upper of more or less crystalline limestone beds (Nos. 14-7) and a lower of alternating shales and dense limestones (Nos. 6-1). While the former is fairly uniform in character the latter shows considerable lithologic variation in short distances. This is due to the change in relative amounts of limestone and shale in the division rather than to the introduction of any other types of sediments. The limestone is clearly in lenses, or in nodules of lenticular shape, so that adjacent sections bear but little resemblance to one another. In the northwest part of section 3, Aux Sable Township, the exposure shows but two 6-inch lenses in 4 feet of strata below the lowest crystalline limestone, while at the next bend upstream, 100 yards distant, the outcrop shows seven such lenses in 6 feet of beds. From this latter outcrop it is clear that the lower group may be extended to include an additional 3 feet of strata, making the total thickness exposed approximately 20 feet.

Differences in the degree of weathering of these dense limestone lenses result in marked color variations which, not being confined to certain beds, confuse rather than clarify stratigraphic distinctions.

Local up- or down-warps of these beds bring in one place the crystalline limestone beds, in another the dense limestone-shale phase to the surface, but so far as can be determined no beds stratigraphically above or below the section given are exposed. Dips as high as 5° are maintained for a few feet, but the dip in one direction is in every instance compensated by dip in the opposite direction within a short distance.

The fossil content of these beds is of great interest. A considerable number of species of crinoids, bryozoans, brachiopods and trilobites are represented in the exposures which have not yet been given the detailed study they deserve. No attempt was made in this investigation to collect fossils systematically, but the great profusion of bryozoan forms was frequently noted as a characteristic of the strata of this formation.[8] Aside from these and the crinoids, neither of which were especially studied, the more common forms were the following:

Bellerophon sp.
Calymene senarius
C. christyi
Dalmanella sp. cf. Meeki
Dinorthis subquadrata
Hebertella occidentalis
Isotelus maximus
Orthoceras sp.
Plectambonites sericeus
Pterinea sp.
Rafinesquina alternata
Rhynchotrema capax
Strophomena planaodorsata

South of the Illinois-Michigan Canal and west of the head of Illinois River there is an area in which the Maquoketa limestone is almost at the surface. In the south half of section 22 rock was met at shallow depth in digging the canal. Along the road a few rods to the south the limestone comes to the surface for a quarter of a mile. Here it has the usual pinkish-buff color on exposed surfaces. Fresh samples show this to be medium fine-grained (average less than 1 mm. diam.) relatively pure limestone, medium gray, and containing irregular veinlets of calcite. The hand lens reveals scattered grains of pyrite (one to a square inch) and less commonly small black particles of an undetermined substance. Some loose fragments showed the stylolitic structure noted in the uppermost beds of the Aux Sable Creek section.

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[8] Mr. C. R. Schroyer, formerly of the Illinois State Geological Survey, has studied this bryozoan fauna extensively. His report, not yet completed, describes many new forms. (Personal communication.)

About eight feet of crystalline limestone is exposed in the south bank of Illinois River in section 26 of Aux Sable Township (T. 34 N., R. 8 E.). The rock here is similar to that just described and is apparently identical with that of the upper division of the Aux Sable Creek section. The stratigraphic relationship of these beds is not determinable from the outcrops, although, as will be shown later, the Illinois River beds are probably some 30 feet higher in the geologic column than those of Aux Sable Creek.

Other exposures of this crystalline limestone are found on the south bank of Illinois River in section 25, along the road in sections 34 and 35, and are reported beneath Pennsylvanian beds on the west bank of Kankakee River in section 36. Southward toward Goose Lake, two outcrops, one in section 2 and another in section 11, reveal the presence of this limestone at shallow depths in this part of Goose Lake Township. To the west, south and east, however, it is overlain by strata of the "Coal Measures."

A characteristic of the limestone phases of this formation is the prominence of fossils on weathered surfaces. Not infrequently it is possible to find perfect specimens of *Rafinesquina alternata, Rhynchotrema capax* and other common forms lying loose on the exposed ledges.

Additional data both as to the extent and the lithology of the Maquoketa formation are obtained from study of drill records. The Maquoketa formation underlies the drift in a strip about four miles wide, extending northward from Illinois River. There is no trace of its former extension to the west, but it extends east beyond the quadrangle to the DuPage, where its eastward dip carries it beneath Silurian limestone of Alexandrian age. South of the Illinois there is a tongue-like projection, but slightly concealed by mantle rock, into the area of Pennsylvanian strata, terminating near the north shore of Goose Lake.

Its southward extension, where concealed by Pennsylvanian beds as well as by glacial drift, is problematical. A boring at the Goose Lake plant of the Haeger Brick and Tile Company passed through 50 or more feet of limestone and shale, probably referable to the Maquoketa. Forty-five feet of shale, referred to this formation, was met in the deep boring at Coal City, but the relation of these beds to the overlying Pennsylvanian is not clear. Even less satisfactory is the record of a boring on the Holderman farm, section 18 of Goose Lake Township (T. 33 N., R. 8 E.), where the 88 feet of "sandy shale" below No. 2 coal may include some lower Maquoketa shale.

The log of the Walker well, two miles southwest of Mazon, has been interpreted by Cady[9] as including 74 feet of shale of Maquoketa age. But here, as in the Coal City log, the lack of a satisfactory horizon marker for the Pennsylvanian part of the record leaves the position of the lower shales in doubt. There must be admitted, however, the possibility that Maquoketa beds are present in the southeast part of the quadrangle. The bearing of this on the structure of this formation will be noted later in the discussion of the structure of the Ordovician beds.

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[9] Cady. G. H., Coal resources of District I (Longwall): Ill. Coal Mining Investigations Bull. 10, p. 119, 1915.

Within the Morris quadrangle the Maquoketa comprises an upper limestone phase and a lower shale phase. The resistant nature of the former is revealed by the outcrops described above, but the shale phase does not appear at the surface within the quadrangle, although thin shales interbedded with limestone, as previously noted, are exposed in the Aux Sable Creek section.

The thickest part of the limestone member is near the head of Illinois River. The log of a well in section 36 of Aux Sable Township (T. 34 N., R. 8 E.) gives a measured thickness of 44 feet, but a total of 65 feet is probably present in places where the elevation of the surface is correspondingly higher. At the north boundary of the quadrangle the limestone is less than 30 feet thick, a well in the west half of section 27 of Seward Township (T. 35 N., R. 8 E.) shows but 8 feet, while less than half a mile west no limestone at all is recorded above the shale phase. This thinning to the west is obviously due to the erosion of the beds which here dip gently eastward. It is thus clear that the beds of the Aux Sable Creek section lie near the base of the limestone member which has its western limit less than a mile farther west. South of the Illinois, however, where the thickness is more than 60 feet, the outcropping beds are above that horizon by at least the difference in thickness or more than 30 feet. More accurate definition of the stratigraphic relation between these beds is not practicable with the present data.

The lithologic character of the limestone-shale phase of the Aux Sable Creek section, as well as its proximity to the western limit of the limestone member, suggests that this lower phase is the transition zone between the shale and limestone members of the Maquoketa. On this interpretation there is no unconformity between these members.

The shale member has a maximum known thickness of 65 feet, which is maintained uniformly eastward beneath the overlying limestone. West of this protecting cover it thins, extending less than a mile beyond the west limit of the limestone.

Lithologically the lower member is entirely shale, no interbedded limestones having been recorded from borings. It is usually medium to dark gray, soft, thin-bedded, non-calcareous, and without fossils.

While within the quadrangle the Maquoketa shows only the two members already described, well records farther east show an additional mem-

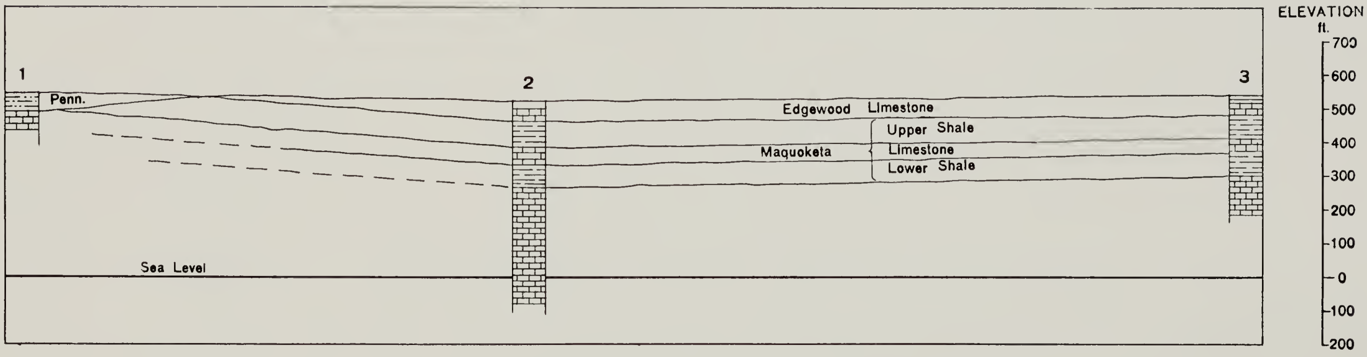

Fig. 19. Southwest-northeast section across Kankakee River near Lorenzo

1. Sec. 18, Wilmington Twp.
2. Sec. 8, Wilmington Twp.
3. Sec. 34, Channahon Twp.

ber, the presence of which has a bearing on the stratigraphy of the area under investigation.

As noted earlier, the Ordovician strata at the east side of the quadrangle have a low eastward dip which carries them beneath limestone of Silurian age. East of the edge of this limestone, as shown by all available well logs, the Maquoketa comprises two shale members, separated by a limestone. These relations are well shown by a northeast-southwest section across Kankakee River near Lorenzo (fig. 19), based on the following data:

TABLE 5.—*Logs of wells near Lorenzo, Will County, showing thickness of strata penetrated*

Formation	Strata	Section 18 Wilmington Township	Section 8 Wilmington Township	Section 34 Channahon Township
		Feet	*Feet*	*Feet*
Edgewood (Silurian)	limestone	eroded	29	33
Maquoketa (Upper Ordovician)	upper shale	eroded	76	75
	limestone	50	52	35
	lower shale	not penetrated	61	80

While the scattered wells show considerable variation in the thickness of the several members, they indicate a thinning of the limestone to the east and north, and even greater thickening of the shale, so that the formation as a whole is thicker.

Since this upper shale is 45 feet thick about a mile east of the Morris quadrangle, it is obviously probable that it extended over the Minooka area at one time, if indeed it does not now. On this point the logs are not enlightening, since the "surface," amounting to about 125 feet, is blue clay till, which might not be distinguished in drilling from the Maquoketa shale. Indeed, it is not improbable that this upper shale may have furnished much of the material of the surface till.

The relations of the Upper Ordovician beds to the overlying Silurian limestones has been noted, but the details of the contact are not involved in the present study since the latter rocks do not outcrop in the area.

With regard to the contact of the Maquoketa and the underlying Galena, but little can be said since the only data are from a small number of scattered wells. There is no indication of discordant relations nor of an erosion surface of even moderate relief. Hence it may be assumed that the contact is essentially a plane surface and represents, if not a conformity, at most merely a slight interruption in the deposition of sediments between Middle and Upper Ordovician epochs.

Elsewhere in the Upper Mississippi Valley the exposed contact of the two series shows concordant relations also, but the fossil content in most places indicates a gap in the record.[10]

PENNSYLVANIAN SYSTEM

Subdivisions of the Pennsylvanian[a]

McLeansboro:
  Calcareous shales, La Salle limestone, Lonsdale limestone, sandy shales, No. 7 coal (locally important).
Carbondale:
  Shaly sandstones, shales, some fine grained limestone, and coals Nos. 6, 5, and 2.
Pottsville:
  Mainly sandstone and shale with some limestone and thin coals, including No. 1 (locally important).

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[a] Italicized formations are represented in the Morris Quadrangle.

The rocks of the Pennsylvanian system belong to the "Coal Measures" or strata associated with beds of coal. They are the youngest solid rock formations of the quadrangle and underlie the drift over the southwestern two-thirds of the area.

Disregarding certain small outliers to be noted later, the north limit of these beds is approximately the Grundy-Kendall county line at the west and the head of Illinois River at the east. This large area, comprising some 150 square miles, probably is divided into two parts at the Illinois valley, at least in the eastern half of the quadrangle, by an old valley now almost filled with sand and gravel (fig. 16).

The presence of surficial deposits renders the exact definition of the northern boundary difficult and on Plate III the contact is placed as accurately as possible on the basis of the well logs at hand. More detailed knowledge doubtless would show greater irregularity in this line, but certain points on it are definitely fixed by exposures.

Inspection of Plate III shows the Pennsylvanian beds to overlie the Galena dolomite at the west, and the Maquoketa formation at the east, without significant difference in elevation. This relation shows that the older beds had been somewhat warped and then subjected to erosion for a period of time before being covered by the deposits of Pennsylvanian age. An examination of the geologic map of the state brings out still more clearly this overlapping of older strata by Pennsylvanian beds.

The Pennsylvanian of the Morris region belongs to a great system of strata of the same period which underlies most of the State of Illinois as well as adjoining parts of Indiana, Kentucky, Missouri and Iowa. This

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[10] Grant, U. S., and Burchard, E. F., U. S. Geol. Survey Atlas, Lancaster- Mineral Point folio (No) 145 pp. 7-8, 1907.

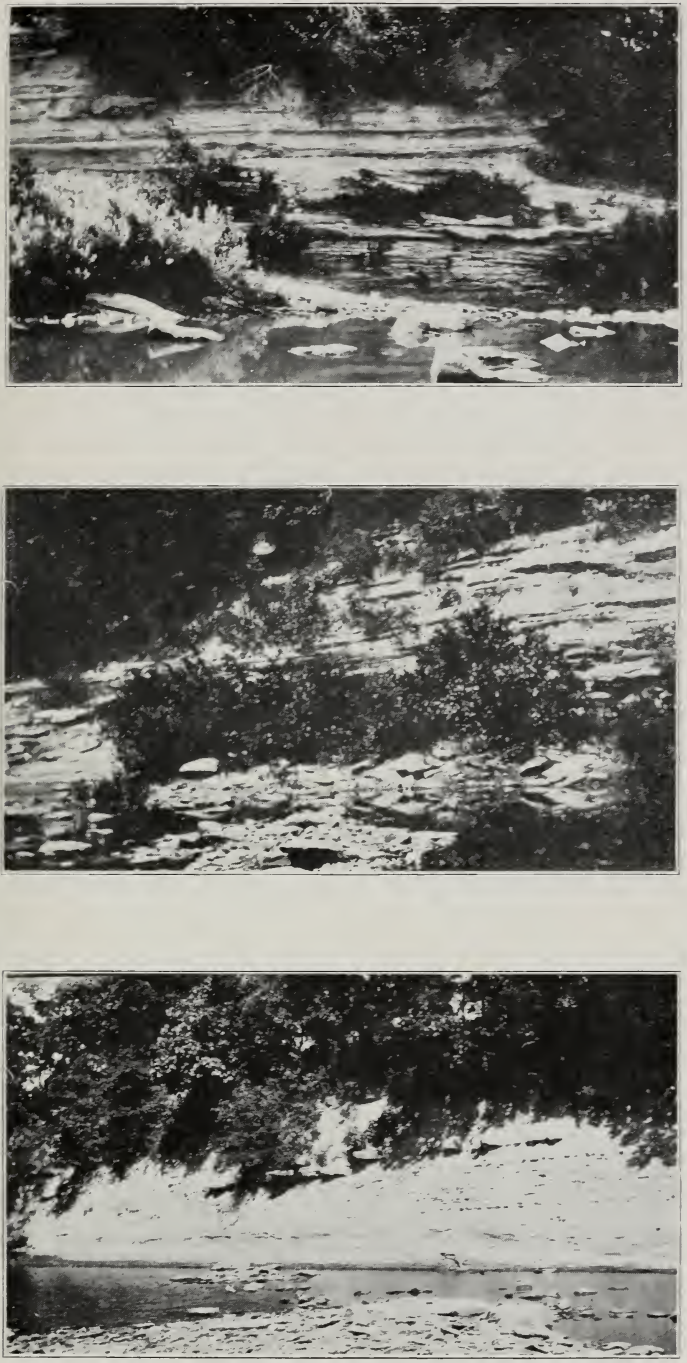

Fig. 20. Carbondale sandstone showing characteristic thin bedding and resistant lenses

whole region is known as the Eastern Interior Coal Basin in distinction from the coal areas of other parts of the United States. This great series of beds occupies a wide, relatively shallow depression, which was the site of deposition of more than a thousand feet of sediments including several valuable coal beds. The basal part of this series is made up of rocks which probably were deposited in fresh water if not in streams. Above these, however, are thin limestones containing marine fossils, which prove that at several times the basin was invaded by the sea. None of these limestones has been recognized in the Morris quadrangle, and hence the marine origin of any of the Pennsylvanian strata there may be questioned. The boundary of the Pennsylvanian beds in the Morris area is a portion of the boundary of the Eastern Interior Coal Basin and the history of the Pennsylvanian beds here, part of that of the larger area. The beds which outcrop in the vicinity of Goose Lake are essentially continuous beneath the whole basin and come to the surface again at the extreme southern limit of the basin in the area west of Shawneetown. Examination of the exposed strata in the Morris region, therefore, is of interest in connection with studies of the Eastern Interior Basin as a whole.

Pennsylvanian rocks are exposed in more or less isolated patches in most of the area which they underlie. The outcrops are almost wholly restricted to the courses of streams and hence are absent in the southwestern part of the quadrangle where the thicker drift covering has not been cut through. North of Illinois River the beds are exposed (1) on Aux Sable Creek in three places between the Rock Island tracks and the Illinois-Michigan Canal, (2) on East Fork of Nettle Creek in the city of Morris and (3) on Nettle Creek in sections 6 and 7 of Erienna Township (T. 33 N., R. 7 E.). More extensive exposures are found south of the Illinois, (1) along Waupecan Creek in Wauponsee Township (T. 33 N., R. 7 E.), (2) along Mazon River and its tributaries from Pine Bluff Bridge to the south limits of the quadrangle, (3) within the Goose Lake depression and (4) along the Kankakee from the county-line bridge to the head of Illinois River.

The outcropping beds are mainly sandstone, shale and intermediate types of rocks, with some bituminous layers, but almost no limestone.

The sandstones are variable in texture, the purer ones being rather coarse. Light gray when fresh, they show a wide range of weathering colors, buff or brown being the most common. Few beds are massive, most of the sandstones are thin-bedded, and cross or current bedding is extremely common. (See fig. 20.) Ripple-marked bedding planes are not rare. Calcareous and ferruginous concretions of nodular or lenticular shape occur at irregular intervals in the beds. (See fig. 21.) These range from minute masses to those measured in rods. In composition the sandstones show little variation. They are composed of quartz grains with abundant mica, but without conspicuous amounts of other minerals. A calcareous cement is common, so that brisk effervescence results from the application of dilute hydrochloric acid. With increase in the amount of argillaceous matter, they grade into shaly sandstones and from those into sandy shales (fig. 22). These are rocks of finer texture but similar to the sandstones in color, structure and weathering effects.

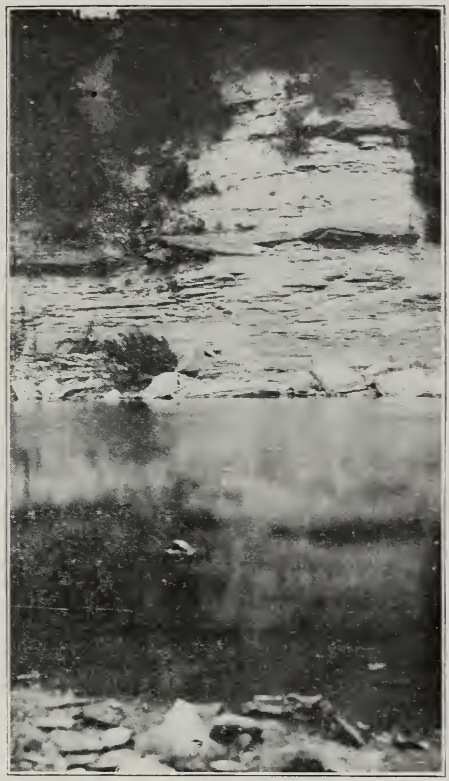

Fig. 21. Lenticular concretions in Pennsylvanian beds along Mazon River

The shales are of very fine texture where pure, but coarser where gritty, and in some cases have an appreciable content of calcium carbonate. In color they range from very light gray to black, being blue, green or even red in some beds. The amount of organic matter present is greater in the darker shales, reaching a maximum in the black bony layers commonly associated with beds of coal.

In thickness these beds range from less than 10 feet at the northern limit of the Pennsylvanian area to more than 200 feet farther south. This increase is not gradual, however, because of the unevenness of both upper

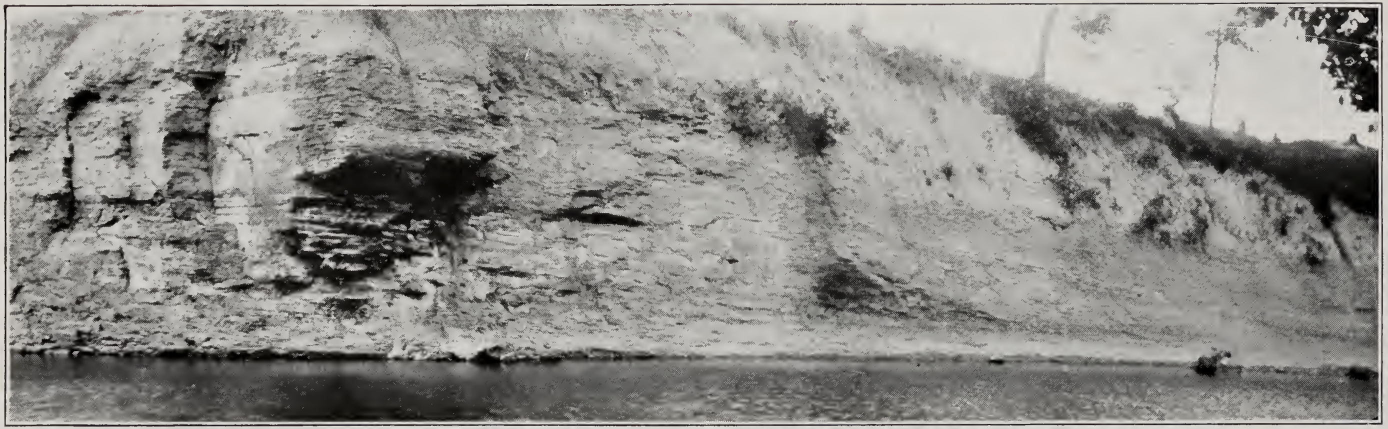

Fig. 22. Typical sandy shale of the Carbondale formation

and under surfaces. The former shows a total relief of at least 80 feet, with a maximum of 50 feet in one mile. The undulatory character of the lower surface is well shown at the contact of the Pennsylvanian and Ordovician strata on the west bank of Kankakee River. From a study of field relations of these beds in the adjoining region, it is clear that there is at least 20 feet difference in the elevation of the base of the Pennsylvanian within short distances. Well records show a similar surface in the region to the west and south. The lower surface is not known in detail south of Illinois River, because the many borings have stopped in most instances at the horizon of No. 2 coal. The unevenness of the surface of this coal is, however, suggestive of even greater relief in the sub-Pennsylvanian surface.

The rocks of this system are not abundantly fossiliferous. Locally a great profusion of forms is found, plant remains being more common than those of animals, which are restricted to certain strata, notably the well-known "fossil beds" of Mazon River. No marine fossils have been recognized and in general the fossils have not been found of stratigraphic value, and no faunal lists have been prepared. It is possible that careful study of plant remains will demonstrate the accuracy or inaccuracy of certain correlations which have been made on structural and lithologic basis.

The Pennsylvanian rocks of the Illinois basin are subdivided for convenience into three formations, which in ascending order are called the Pottsville, the Carbondale, and the McLeansboro. On the basis of an examination of the included fossil plants, David White[11] has determined that the Pottsville formation, which includes all beds below the under clay of No. 2 coal, are of approximately the same age as the Pottsville of the Appalachian fields. Similarly, the rocks of the Carbondale, including all beds between the underclay of No. 2 coal and the top of No. 6 coal are referable to the Allegheny epoch, while the McLeansboro, including the Pennsylvanian rocks above No. 6 coal, corresponds approximately to the Conemaugh formation of Pennsylvania.

These subdivisions can be recognized, at least in part, in the Pennsylvanian strata of the Morris region. The key horizon is No. 2 coal, which is quite generally present, and from which measurements can be accurately made both up and down. This coal marks the contact of the Carbondale and the Pottsville. The separation of the beds of the Carbondale from those of the McLeansboro is rendered difficult because of the absence of No. 6 coal throughout this portion of the State. Certain beds in the southwestern part of the quadrangle, associated with the stratum here called the Waupecan sandstone, are possibly to be classed in the McLeansboro.

POTTSVILLE FORMATION

Rocks tentatively assigned to the Pottsville underlie the drift in a belt from one to four miles wide lying just south of and parallel to the edge of the Pennsylvanian area. (See Pl. III.) The variation in width of the belt is due in part to the difference in thickness of the beds and in part to the difference in their altitude. The only outcrops north of Illinois River are those of Aux Sable Creek, but south of the river the beds come to the surface at Devine, Goose Lake, and on Kankakee River, just above the head of the Illinois.

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[11] White, David, Ill. State Geol. Survey Bull. 8, p. 268, 1908.

All available drill records show the presence of this formation in the area southwest of this belt, No. 2 coal being reported nowhere as resting on the underlying Galena dolomite. As was pointed out in the discussion of the Ordovician system, unusual thicknesses of shale referred to the "Coal Measures" may include some Maquoketa strata. Examination of drill cuttings is the most satisfactory method of determining whether or not the Ordovician is present, but at the present no such samples are available. The character of the strata immediately above the Galena dolomite under most of the area northwest of Coal City indicates that they are Pennsylvanian rather than Ordovician.

CORRELATION

As noted above, definite correlation of Pottsville strata is based upon the presence of the overlying coal bed, which is No. 2 of the Illinois section. In an area where No. 2 is not present, the assignment of beds to a definite zone is attended with difficulty. This is the condition at the margin of the Pennsylvanian area, where so far as indicated by their areal distribution, the strata may belong to the Pottsville, or to some portion of the Carbondale above the zone of No. 2 coal, or to the McLeansboro. While little hesitancy might be felt in assigning to the Pottsville the beds lying north of the city of Morris in this belt, since they contain no coal which could possibly be classed as No. 2, the presence of a coal bed in section 19 of Aux Sable Township (T. 34 N., R. 8 E.) and in the Goose Lake depression makes it necessary to exercise great care in the correlation of the strata in the southeastern part of the belt. Nevertheless, all these beds are tentatively assigned to the Pottsville for the reason noted in the following paragraphs:

1. Strata of undoubted Pottsville age are found a short distance south of this belt wherever the rocks below No. 2 coal have been penetrated. Since they show no thinning at the edge of No. 2 coal it is improbable that they are abruptly terminated there.

2. The lack of similarity of the strata of this belt and those of the known Carbondale area to the south suggests a difference in age. The sandy beds of the northern area are for the most part coarser and less micaceous, composed of less worn and less well assorted material.

3. The coal beds of this belt apparently are not connected with the main body of No. 2 coal. They are distinctly lenticular, pinching out on all sides, and the thick parts are more than twice as thick as the average of

No. 2 coal. The strata accompanying the coal in Aux Sable Township[12] and in Goose Lake are not like those typically associated with No. 2 bed. And furthermore, a bed of limited extent lying 20 feet below the level of No. 2 coal was mined at Jugtown at an early day.

4. Even if the Goose Lake coal be assigned to the horizon of No. 2 coal, the 75 feet of beds underlying it are thus automatically classed as Pottsville.

The thickness of the Pottsville ranges from a few feet at the north edge of the Pottsville belt to about 90 feet northeast of Morris. South of the Illinois records of but few borings penetrating beds below the Pottsville are available and these show from 33 to 75 feet of Pottsville present. North of the river 19 available logs show Pottsville thicknesses ranging from 10 to 89 feet. In general the formation is thinner at the west margin of the quadrangle, thicker toward the southeast, but in all cases thins toward the outcrop. The surface of the Pottsville ranges in elevation from more than 500 feet above sea level near the outcrop to 454 feet at Morris and to a minimum of 376 feet, two miles west of Coal City. The details of the relief of this surface are not known but there is a general slope to the top of the Pottsville toward the south and west.

Lithologically the Pottsville includes sandstones and shales with an inconsequential amount of coal in thin and locally developed beds. There are gradational types between sandstone and shale, as well as calcareous and bituminous varieties. Exposures of Pottsville beds are mainly of sandstone, although the more extensive outcrops reveal interbedded shales, which have not sufficient resistance to weathering to give rise to independent outcrops. A good section, of more than 40 feet, may be constructed from a discontinuous exposure on the Kankakee in section 1 of Goose Lake Township (T. 33 N., R. 8 E.) and in adjoining sections up and down stream. The section follows:

Pottsville section exposed along Kankakee River, Goose Lake Township

	Thickness	
	Ft.	*In.*
Sandstone, shaly, thin-bedded but including abundant sandstone concretions	15	..
Shale, gray, in part carbonaceous, and black, with some black plant fragments	12	..
Sandstone, light gray, coarse grained, including a gray to black shale with abundant plant fragments	4	..
Shale, dark brown, weathering yellow and pink	1	6
Clay, light greenish gray, bedding marked by prominently jointed resistant calcareous lenses	12	..
	46	6

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[12] Bradley, Frank H., Geol. Survey of Illinois, Vol. IV, p. 198, 1870.

There is an exposure of beds probably below these and possibly well toward the base of the Pottsville on Aux Sable Creek, where crossed by the Illinois-Michigan Canal. The sandstone here is gray, medium coarse in texture, and composed essentially of quartz with a sprinkling of a black mineral and fewer red and light-green grains. Mainly finely laminated with excellent ripple marks, some of the strata are more massive, in which case fine, short, carbonaceous streakings are common. Some beds are sparsely fossiliferous. A striking feature is the presence of large sandstone concretions showing prominent cross-bedding, such as were noted at the Kankakee (fig. 23).

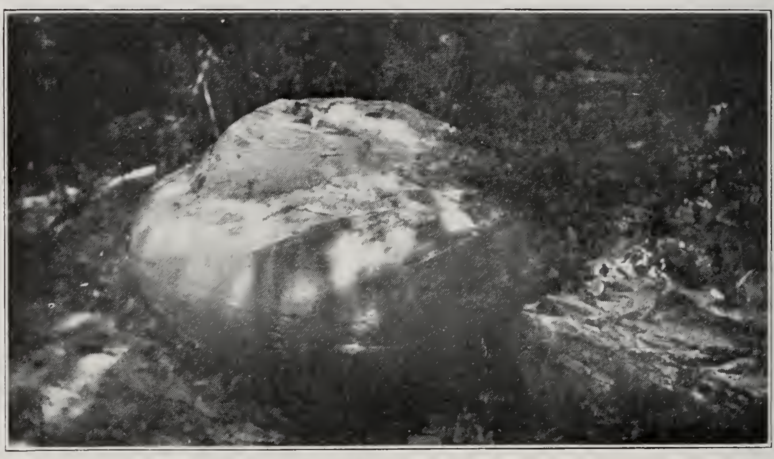

Fig. 23. Spherical concretion in sandstone on Aux Sable Creek

One of the local carbonaceous phases, not rare in the Pottsville, is shown in exceptional thickness in the clay pit of the Haeger Brick and Tile Company at Goose Lake (fig. 24) where the following section appears:

Section of strata in clay pit of the Haeger Brick and Tile Company at Goose Lake

		Thickness	
		Ft.	*In.*
Black swamp beds		3	0
Coal	1 ft. 6 in.	5	7
Clay	9 in.		
Coal	2 ft. 0 in.		
Clay	10 in.		
Coal	6 in.		
"Soapstone", thickness variable		4	0
Sandstone, lenticular		2	6
"Soapstone", thickness variable		0	4
Clay, base concealed		3	0
		15	5

The same or similar coal has been dug about 200 yards to the southeast but there is no indication that either coal extends over more than a few acres.

That the Pennsylvanian system formerly extended farther north than its present limit in the Morris area is suggested by the fact that near its present margin the upper portion has been removed by erosion. This is true not only of the beds above No. 2 coal but of the beds assigned to the Pottsville as well. The earlier extension is further indicated by the fact that in small areas the present surface of the strata shows considerable variation in elevation. For example, in section 34 of Aux Sable Township, sandstone appears above the 520-foot level while the elevation of the surface for two miles north is below 520 feet. It is obviously probable that the lower land to the north was originally covered by beds contemporaneous with the 520-foot sandstone. In view of the fact that the surficial material extends down to or below the 520-foot level for at least four miles north of the sandstone exposure it is evident that the Lower Pennsylvanian beds may have extended that far.

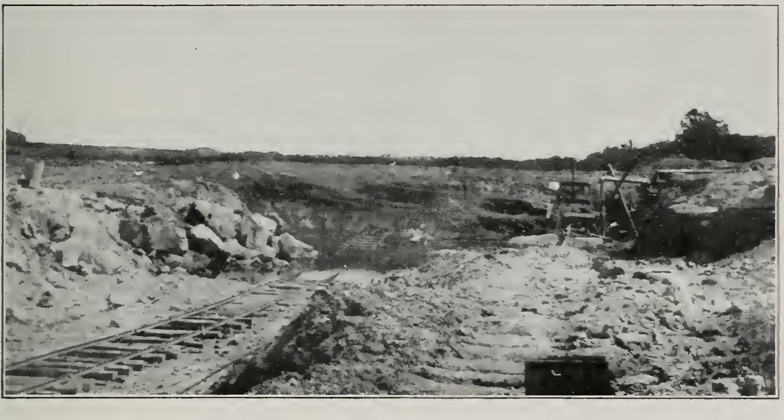

Fig. 24. Pennsylvanian beds in the clay pit at the west end of Goose Lake

Well records in the region are interesting in this connection. A well in the SW. ¼ section 22, Aux Sable Township (T. 34 N., R. 8 E.), showed 6 feet of "soapstone" above the Maquoketa limestone, which was at 503 feet above sea level. Wells in section 24 show the limestone surface nearly 50 feet lower, suggesting that the Pennsylvanian may have been at least that thick in this area. Wells in sections 14 and 9 of the same township showed the surface of the Maquoketa limestone to rise northward, but fragments of clean bright coal in drill cuttings from a well in the NE. ¼ section 9 prove the presence of Pennsylvanian beds at that point. Three miles north of the Morris quadrangle in section 3 of Seward Township (T. 35 N., R. 8 E.), Kendall County, four feet of coal is reported from a dug well beneath 21 feet of glacial drift. This still further extends the limit of former Pennsylvanian covering on Ordovician rocks. While well records indicate the former continuity of Pennsylvanian beds over the area immediately north of the present boundary, it is not clear that the Kendall County coal-bearing beds were connected with these by a farther northward extension, although that is the logical position for the connecting link.

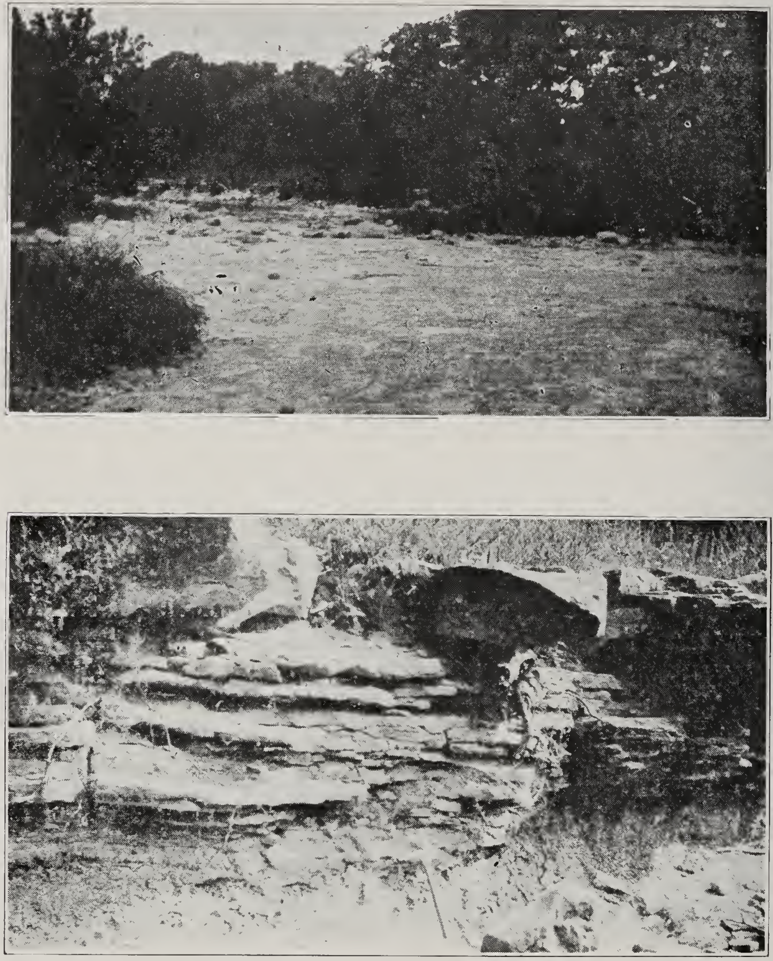

Fig. 25. Exposures of Carbondale beds along Mazon River near Tieders Ford. The lower is a near view of the distant beds shown above

The stratigraphic position of the beds forming these outliers to the Pennsylvanian area cannot be fixed. The scantiness of the lithologic data and the lack of any fossils make exact determination impracticable.

CARBONDALE FORMATION

Beds of Carbondale age underlie the drift over all of the Morris quadrangle south of the belt assigned to the Pottsville. Exposures are limited to the deeper stream channels and hence are infrequently seen north of Illinois River. Nearly 20 feet of these strata outcrop along East Fork of Nettle Creek in the northwest part of Morris, and a similar exposure appears along Nettle Creek in sections 6 and 7 of Erienna Township (T. 33 N., R. 7 E.). No outcrops appear in the channel of the Illinois, but south of the river the Pennsylvanian beds appear interruptedly along Waupecan Creek and Mazon

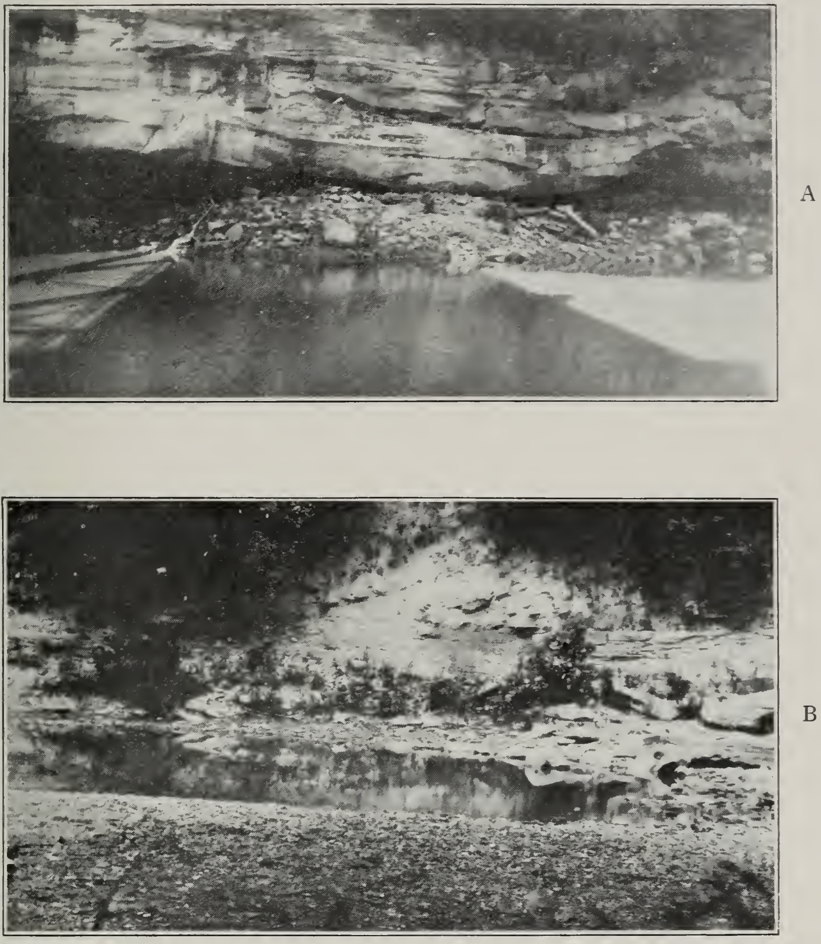

Fig. 26. Typical exposures of Carbondale strata on Mazon River
A. Massive sandstone at Pine Bluff Bridge
B. Thin bedded sandstone in sec. 19, Felix Twp.

River. (See fig. 25.) The latter group of exposures comprises the larger section and includes all beds outcropping on Waupecan Creek.

In general the Carbondale strata are uniform over wider areas than are the Pottsville beds, as indicated by the widespread continuity of the basal member, No. 2 coal. Above the coal lies a variable thickness of shale, sandy shale, and shaly sandstone with but little pure sandstone and almost no limestone. In the latter feature it differs markedly from the typical McLeansboro in which calcareous beds are prominent. The thickness of the Carbondale varies from 10 feet at the northeastern margin to about 150 feet in the deeper parts of the basin. This variation is due to a combination of factors,

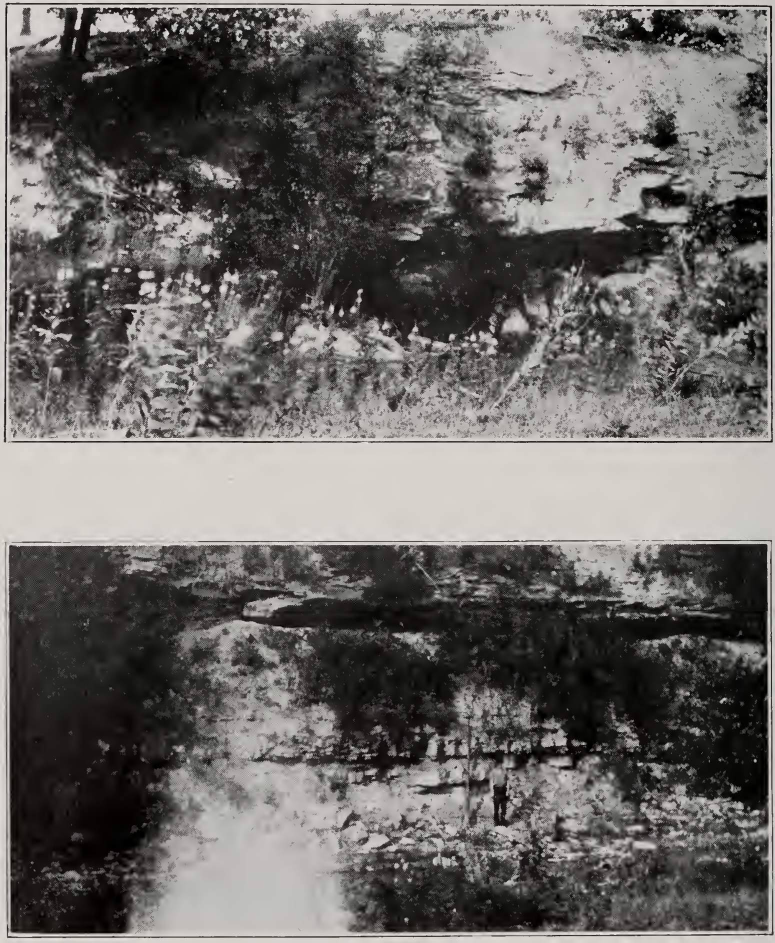

Fig. 27. Waupecan sandstone and underlying beds on Waupecan Creek. The contact is marked by the undercutting below the massive sandstone.

the two most important being differences in original thickness and in the amount of subsequent erosion. A difference in the elevation of the surface of No. 2 coal of about 50 feet occurs two miles west of Coal City. This has been interpreted as a synclinal structure,[13] but may possibly be explained as an original inequality in the surface of the basin of deposition, since the coal here is more than 30 inches thicker than outside of the trough. In any event it causes a corresponding difference in thickness of the formation. Similar but less marked relief in the surface of No. 2 coal with corresponding variation in the thickness of the overlying beds occurs in the vicinity of Morris.

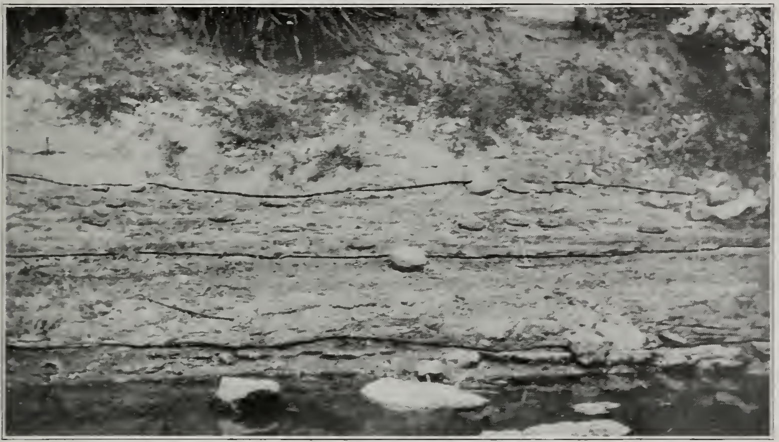

Fig. 28. Exposure showing beds below Waupecan sandstone: the shales bearing nodular limestone are at the water's edge. Mazon River, sec. 6, Maine Twp.

Although uniform in their general characters, the exposures of these rocks reveal marked lithologic differences. These are in part differences between different parts of the formation and possibly in part differences in phases of the same beds. Thus the section at Pine Bluff Bridge shows relatively massive beds of cross-bedded sandstone (fig. 26). An equally thick section a few miles upstream, as in section 19 of Felix Township (T. 33 N., R. 8 E.), shows only shales and sandy shales. Another exposure may reveal sandstone underlain by gray shales, black fissile shale or in places a thin coal bed. Similar but less marked differences appear in what seems to be the same part of the formation. Thus the plastic shales including the fossil beds of section 13, Wauponsee Township (T. 33 N., R. 7 E.), are distinctly sandy in the upstream portion in section 24, so that although apparently belonging in the same stratigraphic zone the two sections are lithologically distinct.

The details of the stratigraphy of the Carbondale formation are not readily ascertained from even such good exposures as lie along Mazon River.

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[13] Cady, G. H., Coal Resources of District I (Longwall): Ill. Coal Mining Investigations Bull. 10, p. 73, 1915.

It is impracticable, therefore, to attempt to present a detailed section, although a generalized column is possible from present data. This includes the following members:

Generalized section of Carbondale formation

		Thickness *Feet*
4.	Sandstone and shaly sandstone	10—25
3.	Shale, including carbonaceous beds	15—25
2.	Sandstone and shale	65—100
1.	No. 2 coal (average)	3

Evidence is fairly clear as to the presence of at least one break in the sedimentary record of the Carbondale in this area. It is at the top of No. 3 of the above section and is marked by a distinct change in the character of deposit and possibly by an uneven contact. The base of the sandstone of No. 4 in many places clearly occupies an erosional depression in the lower beds, but in other places the relations are by no means clear. (See fig. 27.)

The section just below this stratigraphic break comprises the distinct and easily recognized group of beds which are listed below:

		Thickness *Ft.*	 *In.*
6.	Shale, black, weathering to a flaky incoherent mass	3	
5.	Shale, black, fissile, with spherical pyritic concretions	2	
4.	Shale, soft, bony, grading below to black flaky shales which are gray at base	3	
3.	Sandstone, black, coarse, locally conglomeratic		1
2.	Clay, green, soft, plastic, with embedded limestone masses, nodular or lenticular	2	
1.	Shale, gray, soft, thin-bedded, base concealed	1	
		11	1

Considerable variation in the thickness of the several members is noted, but the sequence appears to be without essential variation. Figure 28 shows portions of beds 6, 5, 4, and 2, No. 3 being indistinguishable here. Portions of the fissile shale show an excellent development of cone-in-cone structure and are distinctly calcareous (fig. 29). The contact of the sandstones with the underlying shales is extremely irregular as shown in figure 30. This unevenness seems to be in part due to erosion and in part to the concretionary development both in the sandstone and in the fissile shale.

This break above No. 3 of the preceding section has been followed from the vicinity of Sulphur Springs School west and north beyond Seneca, but the heavy covering of drift prevents its exposure to the southwest. The presence of a similar section in borings near Verona suggests the continuity of these beds and the included stratigraphic break over an area of at least 100 square miles. The limited zone of beds involved in the break, however, strongly suggests a localization of the controlling conditions.

Two members of the Carbondale are thus recognized. The lower comprises No. 2 coal and the overlying sandstone and shale beds with locally developed coal at the top. Only the upper portion of this member outcrops along Mazon River, but drilling shows it to be from 80 to 125 feet thick. The upper member includes sandstone and overlying sandy shale to a thickness of 25 feet. These beds are typically exposed along Waupecan Creek and appear also on Mazon River near Sulphur Springs. It will be called the Waupecan sandstone in this report. A development of "millstone" concretions is common if not characteristic of this member (fig. 31).

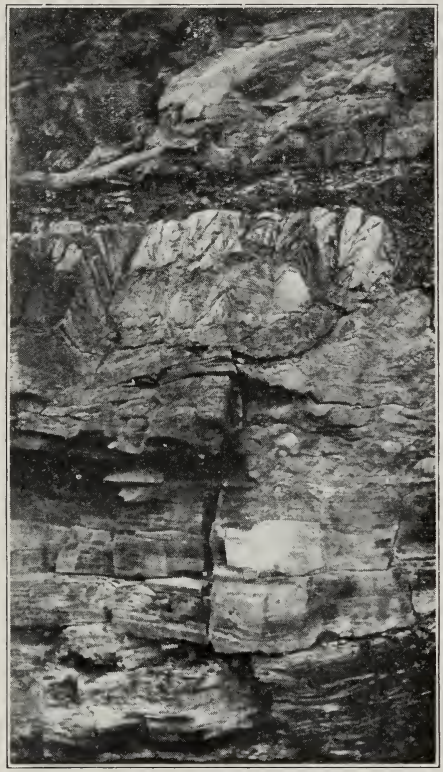

Fig. 29. Fissile shale showing calcareous phase with cone-in-cone structure. Mazon River opposite Johnny Run

By definition the top of the Carbondale is marked by No. 6 coal, which is recognized by the overlying limestone stratum. In the Morris area, however, neither the coal nor the limestone marker of that horizon is present, and consequently the stratigraphic position of the upper beds of the formation as exposed in this quadrangle is somewhat in doubt. If No. 6 coal was ever laid down in this region it apparently has been removed by erosion.

Consequently the present top of the Carbondale section presumably lies stratigraphically below the horizon of No. 6 coal.

Although the Waupecan sandstone may belong to the Carbondale, as stated above, in the absence of a definite marker for the top of that series, it may also be considered to represent the McLeansboro in this region. It is clear that the correlation of these strata depends upon the correlation of the included coal beds.

As already noted, No. 2 coal, the base of the Carbondale formation, is remarkably uniform in thickness and character over wide areas. It is readily recognized by drillers and serves as a reliable guide in all stratigraphic studies of the region. In the southwest part of the quadrangle another bed of coal is found from 60 to 80 feet above No. 2. This coal bed outcrops in Mazon River at Tieders Ford in section 36 of Wauponsee Township (T. 33 N., R. 7 E.), and in section 6 of Maine Township, at Sulphur Springs. A coal bed at this horizon also comes to the surface on Waupecan Creek in the SE. ¼ section 20 of Wauponsee Township (T. 33 N., R. 7 E.), where it was worked at an early date, but not much coal was removed. In the latter place it was classed by Bradley[14] as No. 4 seam of the Illinois section, while at Sulphur Springs outcrop it is commonly classed as No. 7 coal by drillers and others. The latter correlation is based on similarity of lithology and stratigraphic sequence of this section with that near Cardiff where a bed about 60 feet above No. 2 has been called No. 7. The fact that there is considerable uncertainty in regard to the validity of the correlation at Cardiff lends doubt to the feasibility of extending it farther west where the relations are still more obscure.

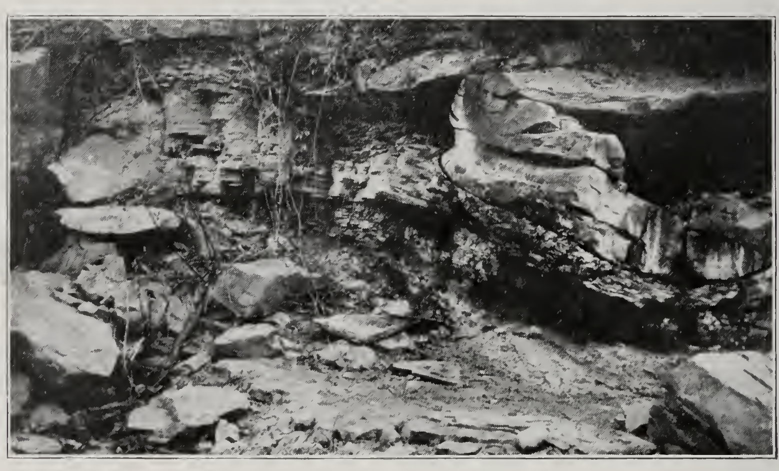
Fig. 30. Uneven contact of Waupecan sandstone with underlying shales, Mazon River opposite Johnny Run

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[14] Bradley, Frank H., Geol. Surv. Ill., Vol. IV, p. 194, 1870.

However, if this coal is No. 7, then the Waupecan sandstone belongs within the McLeansboro. The Waupecan sandstone, on the other hand, can be traced along its outcrop northwestward nearly to Marseilles. It has the lithologic character and apparently the position of the Vermilionville sandstone of Cady,[15] which he finds overlying an erosion surface within the Carbondale at about the horizon of No. 5 coal. In fact, there seems little doubt but that the Waupecan and the Vermilionville sandstones were contemporaneous.

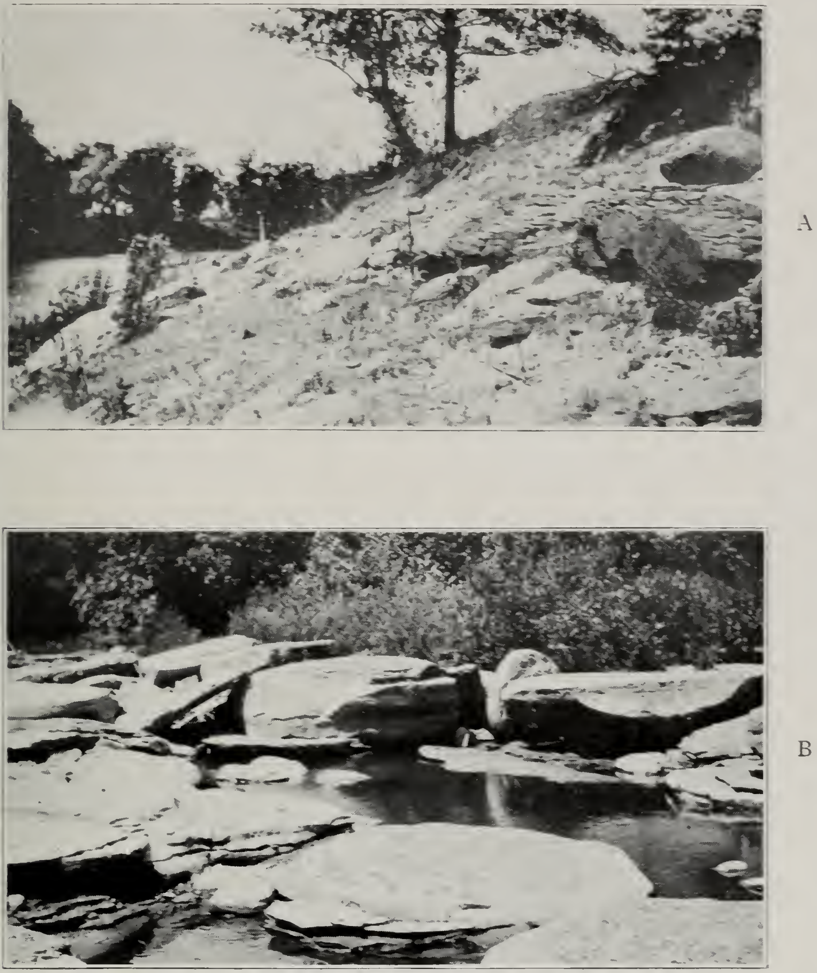

Fig. 31. "Millstone" concretions of Waupecan sandstone
A. In place
B. Dislodged by undercutting in shale

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[15] Cady, G. H., Geology and mineral resources of the Hennepin and La Salle quadrangles: State Ill. Geol. Survey Bull. 37, p. 57, 1919.

The correlation of the Sulphur Springs coal with No. 7 of the Illinois section appears unwarranted and its assignment to a position between No. 2 and No. 5 coals is more in harmony with the data at hand. On this correlation all beds in the Morris area above No. 2 coal belong to the Carbondale. It must be remembered, however, that the coal bed in question is only locally developed and shows marked variation in thickness so that positive correlation can not be made at the present time.

In one boring in section 14 of Braceville of Braceville Township (T. 32 N., R. 8 E.), a thin bed of coal was found about 20 feet above No. 2 coal. This lies between No. 2 and the bed which has been called No. 7. This bed has not been recognized in any other log from the Morris quadrangle, and may fairly be regarded as a northern extension of one of the lower beds of the Cardiff field.

One other formation in this Carbondale section is worthy of more than passing mention. The fossiliferous shales of Mazon River, from the great variety of forms as well as the perfection of their preservation, have become famous among paleontologists and collectors generally.

These beds are exposed prominently in the banks of Mazon River at two localities. The first is along the north-trending part of the stream, in the SE. ¼ section 13 of Wauponsee Township (T. 33 N., R. 7 E.); the second is about two miles upstream just above the sharp bend in the SE. ¼ NW. ¼ section 30, Felix Township (T. 33 N., R. 8 E.).

These beds are shales, mainly without grit, although somewhat sandy in places. They are gray, becoming brown and plastic on weathering. They are finely laminated and in most places cut by many intersecting joint planes. The striking lithologic feature is the presence of great numbers of brown-coated ironstone concretions. These are of varied shape, but invariably have the shortest diameter normal to the bedding planes. Although one or two layers are to be noted, the concretions show almost no regularity of disposition, appearing irregularly throughout the beds. Within the concretions, but not elsewhere in the formation, are the organic remains for which these beds are noted. Without apparent exception the concretions enclose some organic matter, such as a bit of plant or shell, and in some instances a whole leaf is found. Much more rare are the concretions containing a whole insect or fish skeleton. The perseverance of the collectors is indicated by the fact that nearly a score of species of cockroaches have been named from specimens found here. The fossils thus formed show remarkably perfect preservation, so that examination and classification are greatly simplified. The concretions show bedding planes running through them, along which they are usually readily broken. In fact, the failure of an experienced collector to break a concretion cleanly through the middle is commonly taken as indication that the concretion is without a well-preserved fossil.

Pleistocene System

That the reader may have a proper understanding of the references to early Pleistocene history in the following discussion, it is necessary that he bear in mind the complex nature of the glacial history of the region. An examination of the deposits of the United States shows that there have been no less than 13 recognizable stages and sub-stages in the time which is called the Glacial period. For convenience, these subdivisions, numbered in the order of their age, are listed in tabular form:

No. XIII.	The Champlain sub-stage (marine)
No. XII.[a]	The Glacio-lacustrine sub-stage
No. XI.[a]	The Later Wisconsin (the sixth advance)
No. X.	A deglaciation interval (not named)
No. IX.	The Earlier Wisconsin (the fifth advance)
No. VIII.	The Peorian (the fourth interglacial interval)
No. VII.	The Iowan (the fourth invasion)
No. VI.	The Sangamon (the third interglacial interval)
No. V.	The Illinoian (the third invasion)
No. IV.	The Yarmouth (the second interglacial interval)
No. III.	The Kansan (the second invasion)
No. II.	The Aftonian (the first known interglacial interval)
No. I.	The Nebraskan (the earliest known ice invasion)

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[a] Represented in Morris Quadrangle.

It should be recognized that these stages represent intervals of time which were by no means equal, the earlier ones being markedly longer than the later ones. Furthermore, because the Wisconsin ice sheet was the last of the ice invasions, it is possible to distinguish the deposits made at different stages of this advance and recession.

PRE-WISCONSIN DRIFT

Although the Morris region must have been covered by the Illinoian and some of the earlier ice-sheets and hence presumably received more or less deposit therefrom, there is scant evidence of any deposit of pre-Wisconsin age now to be found. A suggestion of the presence of such early deposits is found, however, in the occurrence of fragments of tree trunks in borings. Drilling has also shown the rock surface below the drift to be distinctly uneven, as though trenched by stream valleys. While not enough drilling has been done to define the course of these depressions, it is evident that they are rather sharp and steep-sided in many places. Such depressions, especially if trending in a northwest-southeast direction, would have been filled with the debris from the earliest glacier passing over the region and in many instances probably would retain part of this deposit to the present. It is thus clear that although over most of the quadrangle the bed rock lies relatively close to the surface, even there the valleys which antedated the Wisconsin ice-sheet may hold remnants of an earlier glacial deposit.

WISCONSIN DRIFT

Beginning with the oldest, the more important drift deposits of the Wisconsin epoch are known as the Shelbyville, Champaign, Bloomington, Marseilles, Minooka, Valparaiso, and Lake Border drift sheets. The above-named drift deposits comprise those of both the Early and Late Wisconsin ice. Late Wisconsin time, as now classified, began with the advance of either the Marseilles or Minooka ice-sheets, but the evidence for the separation of the Early Wisconsin and Late Wisconsin deposits is not clear.

BLOOMINGTON DEPOSITS

Of the several drift sheets of Wisconsin age, none earlier than the Bloomington is known to be present in the Morris region. In fact, Bloomington till has not been recognized within the quadrangle, although it is found in considerable thickness less than four miles west in the valley of Hog Run in section 29, Norman Township (T. 33 N., R. 6 E.). Where known, the Bloomington till in this region lies beneath the Marseilles drift. If restricted to this position, as seems likely because of the thin drift cover over most of the area, it will be found only in the southwestern part of the Morris quadrangle, perhaps only west of Waupecan Creek. In this area most of the streams have not yet cut deeply enough to disclose any pre-Marseilles drift. Careful search along Bills Run, which has a steep-sided valley 60 feet deep, failed to reveal any drift not evidently of Marseilles age. Bloomington till may be present, but if so, is concealed by slope-wash or vegetation.

Like all such deposits, Bloomington till is gritty, and carries numerous boulders. It is distinguished readily from the overlying gray Marseilles till by its pinkish color, and in almost all exposures it is more compact than the later till. As found in Hog Run, the exposure nearest the Morris area, this till is about 20 feet thick and in the region just west of Waupecan Creek it is presumably somewhat thinner.

Lacustrine clays.—Overlying the Bloomington till is a thin series of sands, gravels, and lacustrine clays of pre-Marseilles age. While neither the lower till nor the gravels is found within the Morris quadrangle, lacustrine clays are found (1) in the valley of the East Fork of Nettle Creek in the NE. ¼ section 4 of Morris Township (T. 33 N., R. 7 E.), (2) along the town-line road at the north line of section 4, and (3) about 300 yards to the north in a creek bank (Pl. II). The elevation of these clays is just under 520 feet above sea level, which is approximately the elevation of the lower part of the ten feet of clays found over sands, gravels, and Bloomington till seven miles to the west, along Carson Creek in the NW. ¼ section 17, Erienna Township (T. 33 N., R. 7 E.). In character the Morris clays are identical with those on Carson Creek and hence they are believed to represent remnants of the same widespread lake deposit.

The clays are finely laminated, and of various colors, brown, chocolate, pink, green, gray, and yellow. The yellow beds are mostly sandy, but the clays on the whole are not gritty. The laminations are slightly uneven in all parts of the deposit and in places are extremely irregular in thickness and extent. This is particularly true of the thin sandy phases which are interbedded with the clays. In no case was a sandy phase found to extend horizontally more than two or three feet, and in most cases less than one.

The greatest exposed thickness of these clays is less than 20 feet. A well at the tile plant at Morris records 34 feet of clay, but since a streak of coaly matter was encountered at about 20 feet and a fragment of well-preserved wood was found, it is possible that the lower 10 or 15 feet of the "clay" may be Bloomington or some older till. The relation of this deposit to the underlying Pennsylvanian strata suggests its history. The excavation of the clay pit shows the clays to have been deposited in a sharp depression in the sandstone which practically surrounds them. The clays were clearly overridden by the ice of the Marseilles stage, but were protected from removal by the walls of sandstone on all sides.

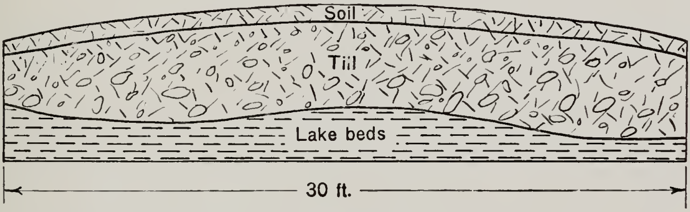

Fig. 32. Section of lake clays beneath till, exposed on south line of sec. 33, Saratoga Township

The outcrop along the town-line road shows clearly the position of these clays beneath Marseilles till (fig. 32), as is indicated by their relations in the clay pit in section 4. Their age, therefore, is post-Bloomington and pre-Marseilles. This determination is at variance with that of Sauer who considered the overlying till to be post-Marseilles in age.[16] Without doubt these clays were laid down in a lake whose surface was more than 530 feet above sea level. Its upper limit is not known from exposures within this quadrangle. The extent of the lake is likewise not known further than that it reached from Morris to Seneca along the site of the Illinois valley.

MARSEILLES DEPOSITS

The next younger deposit is that made during the Marseilles sub-stage. At this time the ice built the prominent ridge which extends in a general north-south direction from Marseilles. The western boundary of the Morris quadrangle coincides approximately with the eastern margin of this morainic ridge, which marks the western edge of the depression known as the Morris basin. East of this ridge the ground moraine of the same ice-sheet appears at the surface except where it has been removed or concealed beneath later deposits. Erosion has nearly or quite removed this ground moraine from a belt two to seven miles wide along the present Illinois valley, and where not removed within this belt, it has been covered by later deposits. Minooka Ridge, too, is of younger drift and conceals the older.

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[16] Sauer, C. O., Geography of the Upper Illinois Valley: Ill. State Geol. Survey Bull. 27, 1916.

The ground moraine of this region is typically blue-gray boulder clay, which is gritty and hard when dry but plastic and sticky when wet. The till is massive and in stream bluffs and road cuts frequently stands in nearly vertical walls. The included boulders are of many kinds. The resistant, well-rounded boulders of crystalline rocks, both igneous and metamorphic, are less abundant than those of limestone which have more or less angular shapes. The sandstone and shale which the glacier must have picked up in passing over the Pennsylvanian terrane were apparently not able to withstand the grinding of glacial operations and were reduced to sand and clay particles which help to make up the matrix of the till. In places the sandy material predominates and not infrequently a cut or boring shows the presence of considerable quantities of an ill-assorted mixture of clay, sand and gravel.

On weathering, the till changes color, the blue giving place to buff and brown. At the same time it loses its content of calcium carbonate, and breaks down to a relatively incoherent mass. Weathering progresses unevenly, the rate being controlled by the topographic position of the till, its porosity, composition, and other related factors. Auger borings show that leaching of the calcium carbonate and other changes of weathering have reached a depth ranging from 20 to 48 inches, averaging about 24 inches for the level till surface. The greater depth to the unleached till in places results from the superposition of a loess-like deposit which may be more than 20 inches thick. This was originally either of leached or readily leached material, and hence is not to be confused with the true till in estimating the depth to which leaching has occurred. In places, a more sandy till shows incomplete leaching to greater depths, more than 120 inches being recorded for a boring on section 19 of Saratoga Township.

The Marseilles drift shows marked variation in thickness. The irregularity of the surface on which it was deposited is a factor in producing the variations in thickness. In general the drift covering is thin in the vicinity of Lisbon, in the Aux Sable valley, and along the Illinois valley, and thicker in the southwestern part of the quadrangle. In the latter area it averages about 60 feet, while at the northwest it feathers out to a veneer of a few inches. Notable variations in this thickness are found which in places suggest the presence of pre-Marseilles depressions of stream origin.

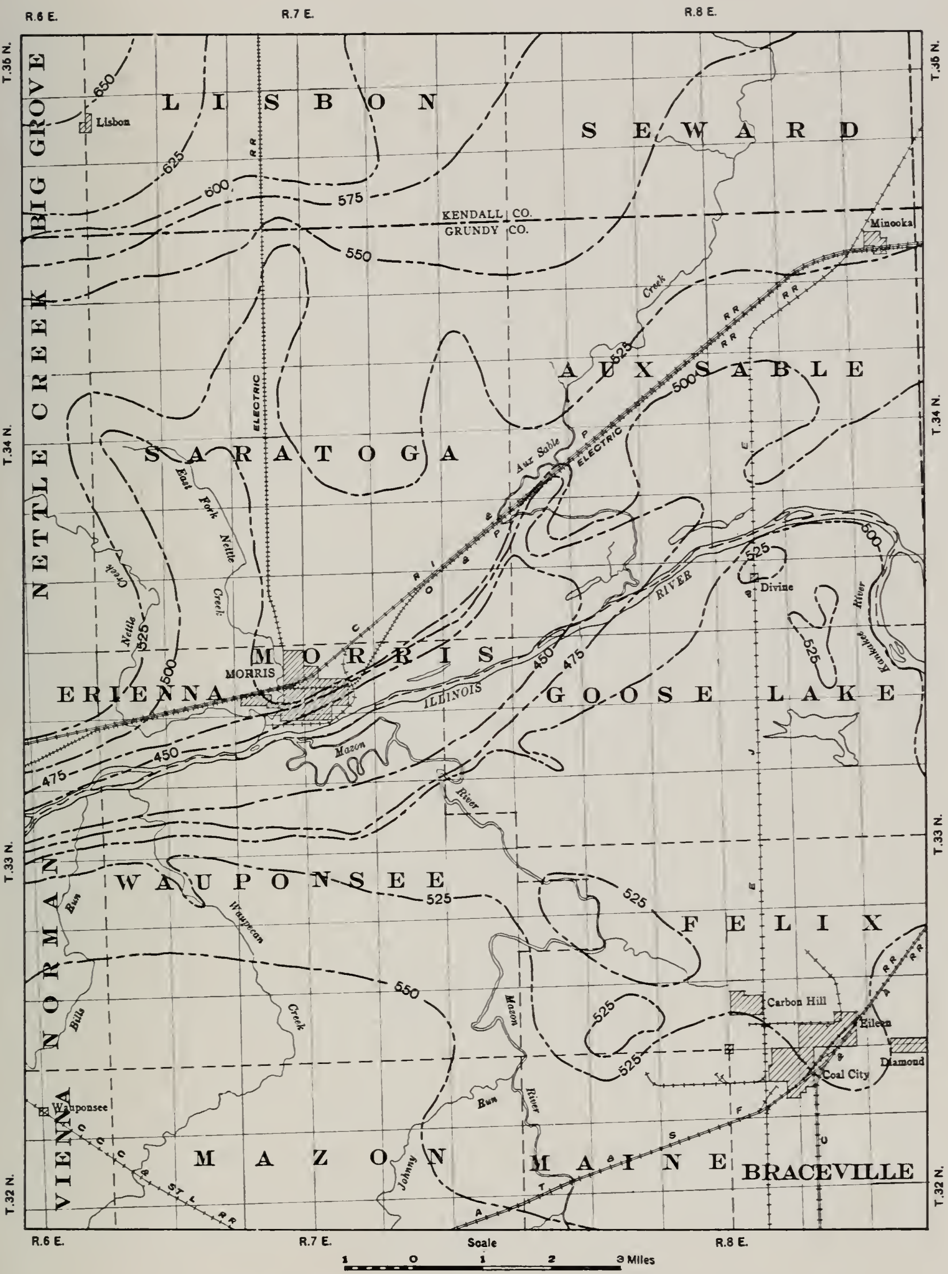

Fig. 33. Map of Morris Quadrangle showing contours on bed rock surface

Although in part developed by post-glacial erosion, the present bed-rock surface, where covered by till, is believed to be essentially the same as that of pre-Marseilles time. On figure 33 are presented contours, based on well records and outcrops, showing the present bed-rock surface.

Topographically, the drift sheet of Marseilles age in this quadrangle has a distinctly subdued expression which apparently is orignal. Certain knolls and ridges appear, but these are prominent by reason of their rarity and serve to emphasize the monotonous topography of the region as a whole. Among these elevations are to be noted a low, uneven-topped ridge trending northeast across the extreme northwest part of Saratoga Township and the adjacent territory. This is little more than a row of elongated knolls which uniformly show slightly worn and poorly assorted sand and gravel on the northwest side and are apparently correctly interpreted as kame-like deposits made when the edge of the retreating ice stopped at that position for a short time. These lie above the 620-foot level in part, and in part between 600 and 620 feet.

Another ridge, more prominent topographically, is in section 13 of Saratoga Township. This is about 20 feet above the adjacent surface and appears to be a till ridge without sand or gravel on top, although a drill record from its west end shows 41 feet of "surface," probably till, with 15 feet of sand beneath and with 15 feet of hard pan between the sand and the underlying rock surface. That this is not a rock hill with till veneer is evident from the fact that the rock surface here is lower than that of nearby outcrops of Ordovician limestone.

About three miles west of Aux Sable Creek and trending parallel to the course of that stream is a series of low-rounded hills of till. Their distribution and character suggest this as the position of the ice front during another halt in its retreat. They may also be interpreted as the deposit made by ice advancing farther than Minooka Ridge, either before or after it was formed. The northernmost of this series of hills appears in the south half of section 21 of Seward Township (T. 35 N., R. 8 E.), Kendall County, about a mile west of Shurtliffe bridge. A small elevation appears just north of this, but whether it is a part of this series or not is not clear. To the southwest there is a hill in section 29, another in 32, another in 31, of the same township, and a possible continuation is noted in a southwest projection of the higher land across the county line in section 2 of Saratoga Township (T. 34 N., R. 7 E.). These are all marked by the 580-contour line. If the interpretation of this series as a recessional moraine is correct, the ice front maintained a position essentially parallel to the Marseilles moraine during its retreat. This would probably involve the continuance of the projection of ice in the valley of the Illinois, and this, in turn, would be an important factor in the frontal conditions south of the valley. The ice in the valley would serve as a barrier between the waters north and south of it, and drainage conditions on either side would be unrelated.

MINOOKA DEPOSITS

This deposit, probably post-Marseilles in age, lies mainly east of the area under investigation, but its west margin encroaches on the Morris area. It covers the earlier deposits over the area north of the Illinois and east of Aux Sable Creek. Minooka Ridge, extending from Dresden Heights northward beyond the limits of the quadrangle, and forming the northeastern rim of the Morris basin, is the outer ridge-like border of the Minooka drift. The origin of the ridge, however, is not clearly indicated by its features as within the Morris quadrangle. These include, (1) a slightly curved trend, convex westward; (2) a steep erosion slope at the south and east; (3) a western slope, less steep and not evidently developed by erosion; and (4) a remarkably flat top about two miles wide.

The prominence of the ridge as viewed from the adjacent lowland, although obviously due in part to recent erosion, strongly suggests a terminal moraine. The absence of the usual topographic features of a terminal deposit and the flat top, which apparently is continued in the upland east of the Des Plaines, favor an origin beneath the ice-sheet rather than at its edge. Possibly the available data are best harmonized in the conclusion that Minooka Ridge represents deposition under the edge of the ice readvancing after a recession from the Marseilles moraine and staying at its line of maximum advance only a short time. Inspection of the extension of Minooka Ridge, especially to the north, where outwash deposits have been reported,[17] may yield conclusive evidence on the question.

This till is bluish or greenish gray in color, weathering to the same buff or light-yellow colors assumed by the Marseilles drift. In fact its chief difference from that drift is the relative scarcity of included boulders. No section of more than 20 feet of this deposit has been observed, the steep slopes of the southern extremity of the ridge being so covered with slope wash and vegetation as to make observation there impracticable (fig. 13). Consequently neither the thickness nor the relation of this till to the underlying material has been determined. The few well records at hand show a uniform thickness of about 100 feet for the material above Ordovician limestone at the south end of the ridge and about 20 feet less at the north end. Whether this is largely or only in small part Minooka till is not known.

The relation of the Minooka ice to that of the preceding Marseilles and of later stages is not clearly shown by data available in the Morris region. Because of the short time involved it makes little difference whether the Minooka moraine be considered as a recessional deposit of the waning Marseilles ice, or as a terminal ridge developed during a readvance of the ice.

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[17] Leverett, Frank, The Illinois glacial globe, U. S. Geol. Survey Mon. 38, p. 322, 1899.

The flat top of the ridge has suggested the possibility that an earlier ridge, possibly of Marseilles age, and formed as a recessional moraine during the retreat of that glacier, was later overridden by readvancing ice which, however, went only a few miles westward, stopping in the valley of Aux Sable Creek. The extraordinary abundance of boulders in this vicinity has been interpreted as the result of deposition by this later ice.[18] No additional evidence favoring this hypothesis has been secured and its retention appears questionable.

FLUVIAL AND LACUSTRINE DEPOSITS

Overlying the glacial deposits just described are certain stream and lake deposits related to the later glacial history of the region. These are referable to certain stages in the development of the Illinois valley, which is now occupied by a descendant of ice-fed streams of much greater volume and power. Plate II shows the topographic relations of the deposits in the Morris quadrangle and Plate IIIA shows their general relations over the whole Morris Basin.

Of these later deposits the oldest has a maximum elevation of about 560 feet above sea level. This is a barely discernible ridge of sand and fine gravel at the junction of the widespread plain above the 560 level, with the prominent flat some 15 feet lower. Associated with this ridge is the silt covering of the lower flat. The only place in the quadrangle where these relations are clear is at Coal City. Here the slope separating the two flats is well marked and the silt and sand deposits of the lower flat reach a maximum thickness of more than 10 feet, 17 feet being recorded in a boring in section 26, Felix Township. These deposits seem fairly interpreted as those of a rather large lake whose surface was about 560 feet above sea level, and whose waters, coming from the melting ice to the east, were dammed at the west by the Marseilles moraine, perhaps near Seneca. Traced southward nearly to Mazon and thence northwestward to the Illinois along the Waupecan valley, the slope joining these two flats becomes inconspicuous, and only in places are the above-described relations suggested. Certain knolls rising above the 560-foot level on the east side of Waupecan Creek in section 28 of Wauponsee Township (T. 33 N., R. 7 E.), suggest by the character of their surface material that they may be remnants of a bar-like deposit related to the deposits in question. North of Illinois River the only traces of any beach deposit at this level are those found on the Nettle Creek road, where a slight accumulation of sand suggests that origin.

Elsewhere within the quadrangle below the 560-foot level silt or sand deposits are suggested in the character of the soil but the original limits of this type of sediment have been altered by slope wash, wind action, and cultivation, so that it is no longer possible to draw the boundaries in detail.

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[18] Leverett, Frank, The Illinois glacial globe, U. S. Geol. Survey Mon. 38, p. 327, 1899.

Topographic details will be added in the summary of evidence on the existence of this body of water presented in connection with the glacial history of the region.

In this connection, it is of interest to note that along the eastern margin of the Morris basin, in Will County, there are remnants of a fairly well-developed beach line at the 560-level.[19] There are also prominent gravel and sand deposits showing in places inclined bedding both south of Wilmington and southeast of Channahon. These apparently mark the mouths of heavily laden streams entering this body of water.

Another group of deposits, still younger, is found at about the 540-foot level. Beach development is much more pronounced at this level than at the 560-foot level and is traceable for miles on each side of the Illinois. There are no considerable deposits now recognized on the lower flat, however. The beach has its best development north of the Illinois, where there is a relatively steep slope joining the flat, which has an elevation of about 525 feet, with the 550-foot flat to the north. The top of the slope is marked by a low ridge having a maximum width of 50 feet and averaging 2 feet high. The ridge is composed of worn pea gravel in a sandy silt matrix, wholly leached of calcium carbonate. The surface north of the ridge is an essentially level plain rising northward about 5 feet to the mile. The surface south of the ridge is slightly undulating with swamp areas suggesting channel scars. Boulders are abundant on this lower flat, whereas they are nearly absent on the higher.

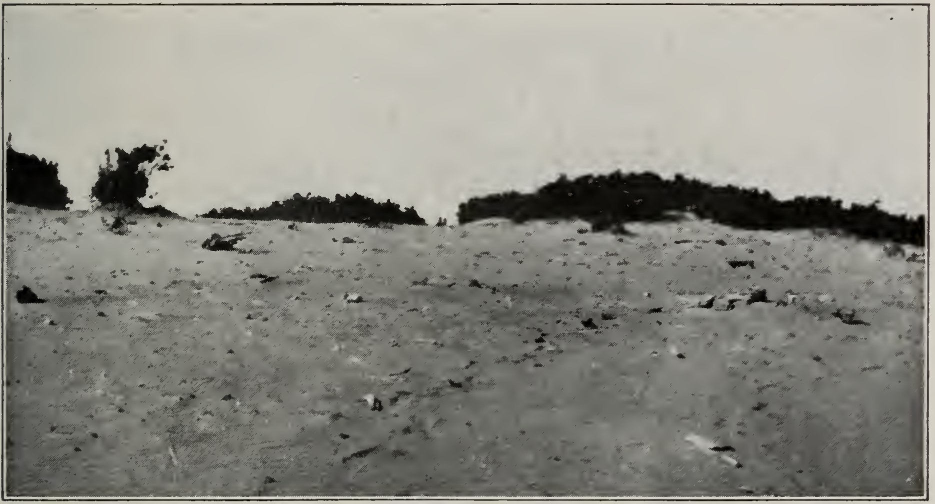

Fig. 34. Dune near east end of Sand Ridge

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[19] The beach line may be seen in sections 1, 2, and 12, Wilmington Township, and the sand and gravel with delta bedding appear at the north line of section 16, Channahon Township. Similar gravels are to be found in sections 17 and 35, same township, as well as in sections 7 and 18 of Wesley Township.

North of the Illinois from a point near the west boundary of the quadrangle as shown on Plate II the 540-foot contour line marks the position of this old beach, remnants of which are readily seen on each side of Nettle Creek and which can be traced along the Ridge Road to Aux Sable Creek. East of this creek the beach topography, if existent, has been obscured by the development of dunes. Farther southeast beyond Sand Ridge, however, the older topography is still discernible, and the beach can be followed across the Elgin, Joliet and Eastern right-of-way to the steeper slopes of Minooka Ridge west of Dresden Run. Here subsequent erosion by Illinois River has removed all trace of the shore line.

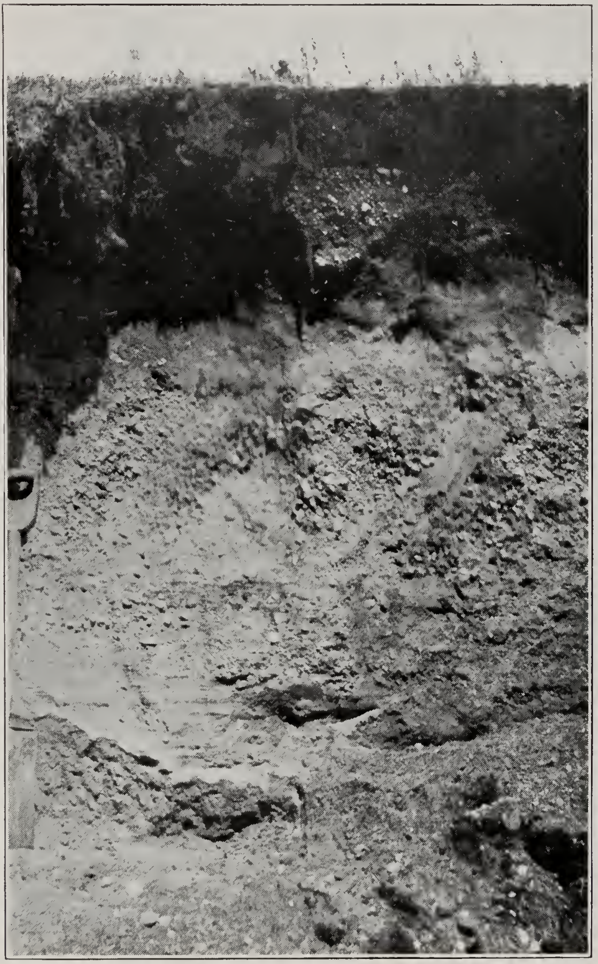

Fig. 35. Gravel pit in NE.¼ sec. 33, Goose Lake Twp.

South of Illinois River remnants of an old beach probably referable to this same body of water are to be seen on both sides of Waupecan Creek. From there eastward the abrupt slope with its crown of gravel and sand may be traced readily as far as Mazon River (Pl. II). Beyond this point all trace of the slope separating the two flats is lost, the surface showing a nearly uniform gradient from below to an elevation above the 540-foot level. The wide expanse of wind-blown sand, having its maximum development in the dune area north of Coal City, known as Sand Ridge (fig. 34), gives a plausible reason for the absence of the beach topography.

East of the quadrangle, in Will County, remnants of this beach line are seen at several points, notably in section 11 of Wilmington Township (T. 33 N., R. 9 E.), so that the combined remnants within the Morris basin enclose fairly completely the area covered by this body of water. Considering the lack of silt deposits on the lower flat and the evidences on its surface, it appears questionable whether this body of water of sinuous shape and some 20 miles long by 5 miles wide should be called a lake. All conditions seem satisfied by considering it to have been a wide river of low gradient, yet capable, because of local expansion to great width, of forming a prominent beach line. The anomalous feature of these beach deposits, the apparent evenness of the beach itself, is not satisfactorily explained. In the absence of exact levels at the top of the beach, however, it is obvious that an existing down stream slope in the beach line may not be apparent from the topographic map.

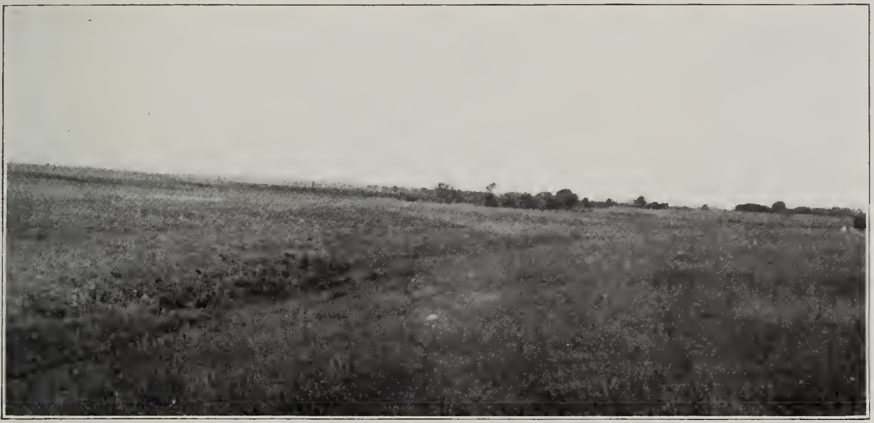

Fig. 36. View in sec. 33, Goose Lake Twp. showing the topographic relation between the present Illinois flood-plain on the left and the earlier gravel deposits on the right. The 500 foot contour marks the junction of the two areas

At a still lower level there are found certain deposits which clearly are of later age and different origin from those previously described. These include sands and coarse gravels which are restricted to a comparatively narrow area on both sides of the Illinois. They lie within a trench, mainly shallow, but locally apparently sharp and deep. In the next higher flat, the junction of the two surfaces is marked in places by a 5- to 15-foot slope. They are only found below an elevation of about 525 feet so that their limit is marked approximately by the 520-foot contour line. That portion below the 500-foot level is in most places covered by deposits of recent time. These beds are quite uniform in character and composition, and are readily assignable to a common origin. While not more than 20 feet is exposed at any point, drilling shows them to range in thickness from two or three feet to possibly as much as 60 feet, thus constituting an important group of beds.

A typical exposure is that found in a gravel pit about a mile west of Divine Station in the NE. ¼ section 33 of Goose Lake Township (fig. 35). The section is:

Pleistocene gravel exposed in sec. 33 of Goose Lake Township

	Thickness *Inches*
Soil, black, sandy, with few pebbles, maximum diameter ½ inch.........	6
Subsoil, gray black, more sandy, pebbles maximum diameter 1 inch......	3
Gravel, dark gray brown, variable thickness, average..................	6
Sand, yellow brown, the lower part finer, clean, with few pebbles of maximum diameter 1 inch, $CaCO_3$ leached..............................	20
Gravel, cross bedded in part, clean, average diameter of pebbles greater than 1 inch. About 50 per cent limestone, the rest igneous and metamorphic rocks, with some chert	30
Sand, locally pebbly, but mainly clean, cross bedded in part exposed	30

Similar beds of gravel and sand were opened in the old city gravel pits at Morris, just north of the junction of the main forks at Nettle Creek. Such deposits have been opened in section 29 of Aux Sable Township (T. 34 N., R. 8 E.), in section 16 of Wauponsee Township (T. 33 N., R. 7 E.), and in scores of places along the Illinois. In fact, they constitute the only local source of clean sand and gravel for this region. The surface of these deposits is slightly more uneven than that of the 525-foot level, and is usually distinguished by its rolling character with bar-like knolls and ridges of sand and gravel.

Overlying the gravels but clearly antedating the recent alluvial deposits of the main valley is a small patch of marl and peaty muck which appear to belong to the closing stages of this 520-foot river. It seems probable that these fresh water beds belong to deposits made in the greatly expanded river rather than in a marginal pond, but there is nothing to indicate whether the water was a lake or river. In the marl bed, uncovered in Bell's stripping near Morris, the following shells are abundant:[20]

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[20] The determination of these shells was kindly made by Frank Collins Baker who offered the following suggestions as to the environment they indicated: "The body of water must have been of considerable size to have supported so large a fauna, but it need not have been very deep. Most of the forms represented are common in water 5-8 feet deep, and a depth of 10-20 feet is sufficient for all the species."

Mollusca from Pleistocene in Grundy County

Planorbis antrosus Conrad
Planorbis antrosus striatus Baker
Planorbis campanulatus Say
Planorbis deflectus Say
Planorbis altissimus Baker
Planorbis exacuous Say
Amnicola leightoni Baker
Amnicola lustrica Pilsbry Variety (new)
Amnicola walkeri Pilsbry
Valvata tricarinata Say
Valvata tricarinata perconfusa Walker
Valvata tricarinata infracarinata Vanatta
Valvata tricarinata simplex Gould
Valvata tricarinata variety (new)
Galba obrussa decampi Streng
Physa anatina Lea
Physa walkeri Crandall
Pisidium, several undetermined species

The relation of these deposits to the earlier ones, as noted above, is one of deposition within a trench cut in the earlier flat. Their relations to later deposits are less simple. The superposition of alluvium of the present Illinois River upon the gravels is shown in the pit at the ice house just south of the Illinois-Michigan Canal at Morris. Here the usual gravels are overlain by about 3 feet of black alluvium which is clearly continuous southward to the river. In fact, the pit is flooded nearly every year. Similar relations are seen in the vicinity of section 5 of Goose Lake Township (T. 33 N., R. 8 E.), where "islands" of sand and gravel projecting above the level of the floodplain constitute prominent knolls. These are outlined with fair accuracy by the 500-foot contour lines (fig. 36).

Modification of these relations through the agency of the wind appears in section 5 of Goose Lake Township, where dune sand is heaped into an east-west trending ridge more than ten feet above the floodplain of the Illinois. This is an active dune area and in its obliteration of the usual topographic relations of the floodplain and the older gravel flat suggests the mode of concealment of topographic forms at the junction of the earlier developed flats at higher levels.

From the composition, structure, and position of these deposits it is clear that they were made by westward flowing streams of such volume and velocity as to be able to transport considerable loads of relatively coarse sediment. Practically no fine material referable to this stage has been found. Hence these deposits are assigned to an early Illinois River of greater volume, though possibly of lower gradient than the present stream.

Genetically related to the foregoing stages of development of the present Illinois valley there are many deposits, individually of small extent but rather large in the aggregate, which occupy slightly elevated positions above the floodplains of the various tributaries, past or present, to the main stream. These are now terraces of coarse or fine materials, usually well stratified and similar to the deposits of the main stream (fig. 37). In many instances they can be assigned to one or another of these three stages of Illinois River which preceded the present stage on the basis of their elevation and geographic position. While it has not been considered important to map these terraces so as to show their relations to contemporaneous deposits made in the main valley, it may be well to point out localities in which the various terraces are well exhibited. Nettle Creek, in section 31 of Saratoga Township (T. 34 N., R. 7 E.) and southward in the north part of section 6 of Erienna Township (T. 33 N., R. 7 E.), shows a series of terraces from 3 to 10 feet high which apparently were developed during the down-cutting of this stream as the Illinois was lowered (fig. 38). Aux Sable Creek and its tributaries, Collins and Walley runs, show such terrace remnants interruptedly throughout most of their valleys in Aux Sable Township (T. 34 N., R. 8 E.). Such deposits have furnished gravels along Walley Run in sections 7 and 18 of this township.

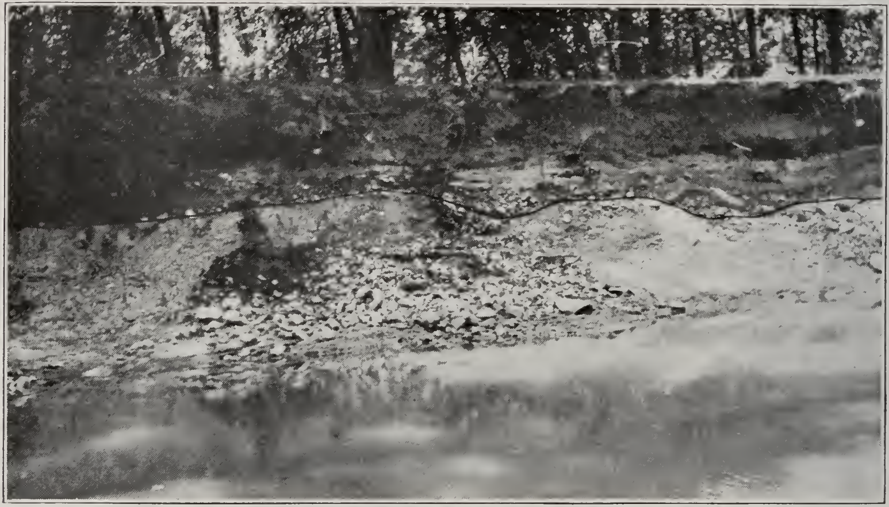

Fig.37. Terrace gravels overlying fresh gray till in bank of Nettle Creek sec. 31, Saratoga Twp. The stratified character of the gravels and sand lenses serves to distinguish them from the massive till below. Note the unevenness of the till surface

South of Illinois River, terraces are found along Mazon River and its tributaries, Claypool Ditch and Johnny Run. Along the Mazon these are especially well developed below Tieders Ford in section 36 of Wauponsee Township (T. 33 N., R. 7 E.). Farther west the same relations hold on the downstream portion of both Waupecan Creek and Bills Run.

As is pointed out in another connection, the trend of the streams themselves is evidence of the sort of adjustment to new levels by which these terraces have been developed.

RECENT DEPOSITS

The deposits of Recent age comprise alluvium of present streams and dune sands. The area of the former amounts to 12 or 15 square miles in the floodplains of the Illinois and its tributaries. This is mainly a black, more or less sandy silt having a relatively high content of organic matter. It provides excellent soil and where drained properly produces good crops. It is restricted approximately to the area lying below the 500-foot level along the Illinois, but appears at somewhat greater elevation along the smaller

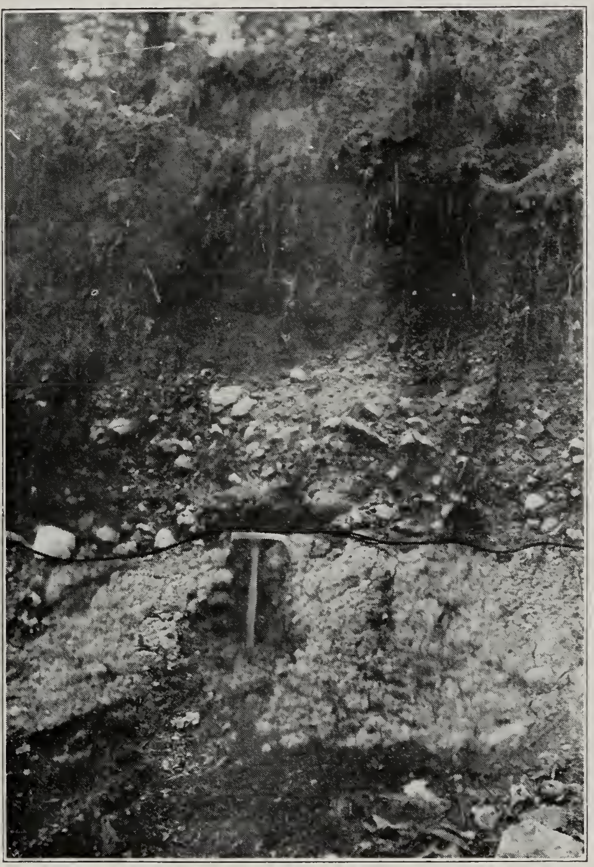

Fig. 38. Close-up of gravels shown in fig. 37. The distinction between the till and the overlying gravels is clear, while the stratification of the latter is less apparent than in the preceding view

tributaries. The dune sands have already been mentioned. The more prominent areas are at Sand Ridge in Aux Sable Township (T. 34 N., R. 8 E.) north of Illinois River, and at Sand Ridge south of Goose Lake. The former is less than one square mile in extent while the latter covers more or less of five sections across the north end of Felix Township (T. 33 N., R. 8 E.) and extends nearly a mile farther into Will County.

Southeast of Coal City the sandy character of the surface is noticeable, although there has been but little dune formation. East of the county line, however, the development of dunes is so marked as to dominate the topography and to indicate the origin of the sandy covering of the surface at all levels in the southeast part of the Morris quadrangle.

Mention has already been made of the limited dune development southwest of Divine Station in section 5 of Goose Lake Township (T. 33 N., R. 8 E.). Here the advancing sand has so nearly buried the original fence posts that a second fence has been constructed above the first.

Average samples of the sands from these several dune areas were collected and subjected to a simple mechanical analysis. The chief points observed were, (1) the fineness, angularity, and uniformity of size and composition in the sand from southeast of Coal City; (2) the relative coarseness of the sand from the southern Sand Ridge, and its content of stony matter; (3) the dark color and wide range in size and composition of the sand near Divine; and (4) the well-rounded shapes and content of calcite in the sand from Sand Ridge north of Illinois River.

While detailed analysis of these data is out of place here, the general conclusions are of interest. (1) It is clear from the differences in shape and composition that these sands did not have a common source just prior to their latest deposition. This, together with the fact that the dunes lie at several levels indicates a difference in age. Although conceivably the dunes were contemporaneous, the inference of a difference in age is borne out by the fact that the most active dunes are at the edge of the present floodplain while those at the 540- and 560-foot levels have been subdued in large part by advancing vegetation. (2) Sand from southeast of Coal City, although angular, probably has been carried by water as indicated by the uniformity in size of the grains. These are probably of smaller size than would be rounded in the course of stream transportation. This favors the assumption that these sands were blown from a delta formed by the Kankakee where it entered Lake Morris. The wide expanse of the sand southwest of Wilmington made possible the development of extensive dunes without the introduction of much foreign material. (3) The sand from the contact of the floodplain of Illinois River with the older gravel flat contains a considerable amount of alluvium with organic matter which does not appear in the other sands. The burden of silt with much organic matter now carried by Illinois

River is obviously of recent origin and must have been acquired in postglacial time. The presence of considerable amounts of this silt in the bordering dunes bears out the inference that these are of late origin.

The sand deposits presumably are not thick. The maximum thickness, as determined by observing the relative elevation of the tops of the dunes and that of adjacent flats, is about 20 feet, but the average is much less, probably less than five feet. If there be included in the dune area that portion surrounding the actual dunes on which surface sand is prominent, the area involved would be several times greater and the average thickness a matter of a few inches.

CHAPTER IV—STRUCTURAL GEOLOGY

The attitude of the rocks of the Morris quadrangle was discussed in part in the chapter on descriptive geology, but in order to bring out the general structural relation the facts are reviewed.

The Morris region is one of nearly flat-lying rocks with few horizon markers. The few outcrops and relative scarcity of well data, in combination with the feature just noted, make accurate determination of structure difficult and detailed determination impracticable, except locally.

The St. Peter sandstone was reached in more than 50 wells plotted on Plate II. Contours drawn on Plate III to show the configuration of the surface of the formation indicate a rather uniform dip to the southeast. That this uniformity is apparent rather than real is suggested by the departure therefrom where more numerous well logs are available, but the general southeast dip of about 28 feet per mile is demonstrated, the altitude of the upper surface of the sandstone ranging from 544 feet above sea level at the northwest to 75 feet below sea level at the southeast.

Comparison of elevations on the upper surface of the Galena-Platteville formation fails to reveal the structure because of the truncation of the beds by erosion. Consequently no difference between the altitude of the St. Peter sandstone and that of the overlying formation can be determined. Whether these beds conform to the Morris-Kankakee anticline noted by Cady[21] is therefore not known. This postulated deformation, however, is merely a broad low arching of the beds, and may prove to be non-existent when more complete data are at hand.

The areal distribution of the Maquoketa formation in the north half of the quadrangle indicates a low east dip which does not exceed and may conform to the dip of the St. Peter sandstone. Well records do not clearly indicate the Maquoketa area in the south half and hence the structure cannot be ascertained.

If the Maquoketa is present in the southeastern part of the quadrangle, as suggested by the interpretation of logs quoted earlier (p. 124), the formation may be assumed to be conformable to the postulated Morris-Kankakee anticline.

The structure of the Pennsylvanian beds as a whole seems to be independent of the low arching just noted. On the basis of the structure of No. 2 coal, the base of the Carbondale formation, the Pennsylvanian beds dip southwest at a low angle and this general attitude is interrupted by a southwest-pitching syncline or basin with very low slopes west of Coal City, and a parallel broad down-warp in the vicinity of Bills Run.

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[21] Cady, G. H., The Structure of the La Salle anticline: Ill. State Geol. Survey Bull. 36, p. 133, 1920.

It thus becomes evident that the rocks of this region have suffered more than one deformative movement. The first here recorded occurred in the interval between the deposition of the St. Peter and the Pottsville beds. This may have been merely a tilting of the surface toward the southeast.

The folding along the Morris-Kankakee anticline, if any occurred, may have taken place in pre-Pennsylvanian time since the later beds do not appear to be involved.

A still later movement followed the deposition of the Pennsylvanian beds of this area. This resulted in the general southeast dip shown by this series. The cross-warping which developed the shallow synclinal troughs of Morris (No. 2) coal may have occurred at the same time or later.

It is evident from their areal pattern as well as their proximity to the line of maximum deformation, that all the rocks of this quadrangle were involved in the series of movements resulting in the La Salle anticline. It is possible, however, that the postulated Coal City arch has been of equal importance in determining local structures. The time and structural relations of these two units is beyond the scope of this report, and it suffices to point out that the movements in this area conceivably were contemporaneous with those listed by Cady for the development of the La Salle fold.[22]

Although the Eastern Interior Coal Basin is a stratigraphic or physiographic rather than structural feature, it is well to note its relation to the Morris beds. As has been pointed out, the general coal basin of which this area is a part comprises most of the State of Illinois as well as parts of the states adjoining on the east, south, and west. The deeper portion of the basin lies in the southern part of Illinois. The old surface of deposition slopes toward this deeper part from all sides. In the Morris area this slope probably was of different angles at various times, through deformative movements, but was probably at no time far from flat. The uniform thickness and character of No. 2 coal for example, indicates essentially uniform conditions for deposition over the entire area where that bed now exists. It is clear, also, that the original margin of the depositional basin was north of the present edge of Pennsylvanian beds. It is not apparent, therefore, that the present attitude of the Pennsylvanian strata is due in any degree to the proximity of the area under investigation to the margin of the basin of deposition.

Minor folding of the pre-Pennsylvanian beds has been noted in the description of those strata. Except where revealed by the limited outcrops the details of these minor and more or less localized structures cannot be ascertained. It is obviously probable, however, that such structures do occur and have their effect in the minor intricacies of the areal patterns and in the disposition of the later deposits as well.

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[22] Cady, G. H., Structure of the La Salle anticline: Ill. State Geol. Survey Bull. 36, p. 175, 1920.

The minor structures affecting the Pennsylvanian strata are of much the same order of magnitude as those noted for the pre-Pennsylvanian rocks. Because of the more extensive outcrops and the development of the coal properties, however, the details are somewhat better known. These structures include some minor faulting as well as folding. In the upper beds of this system as exposed along Mazon River, the usually low and distinctly local warping is so common as to constitute the rule rather than the exception. Such deviation from a flat-lying position as that in the center of section 25 of Wauponsee Township (T. 33 N., R. 7 E.) is typical. Another example may be seen just below the sharp bend in SE. ¼ section 19 of Felix Township (T. 33 N., R. 8 E.), where a monoclinal flexure giving 10° dips affects the beds for a few yards. Similar structures are commonly met in coal-mining operations in this region. Cady[23] has introduced rather detailed descriptions of some of these structures, of which the most important is probably that encountered in the Coal City area where No. 2 coal occupies a trough about 1,000 feet wide and 50 feet deep, trending north-south.

Faulting does not appear to be commonly of more than a foot or two displacement, and no extensive faults have been discovered. Such movements of this type as have occurred are probably referable to local differences in contraction and compression of sediments during solidification rather than to regional stresses. Small dislocations are frequently noted underground, and on the surface where the rocks have an essentially vertical exposure they commonly show similar fractures. Such a one appears just below the bridge at Pine Bluff. Here the vertical component of the movement is measured in inches.

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[23] Cady, G. H., Coal Resources of District I (Longwall): Ill. Coal Mining Investigations Bull. 10, 1915

CHAPTER V—HISTORICAL GEOLOGY

The foregoing presentation of data concerning the character, disposition, and stratigraphic relations of the various formations of the area is the basis for inferences regarding the depositional and erosional conditions in times past which in turn lead to certain conclusions as to the sequence of events in this region. The province of this chapter is the delineation of these events so as to bring out their interrelations.

Of the time earlier than the Paleozoic there is no available record. The geographic position of the Morris quadrangle makes it probable that in pre-Cambrian time this region was subjected to erosion which reduced the land to an essentially plane surface. No drilling records are at hand showing the character of the material composing this surface, but by comparison with the area in Wisconsin, where this old surface is exposed, it becomes clear that below the sediments of Cambrian age lies an unknown thickness of crystalline rocks, probably in part igneous but largely metamorphic. These constitute a lithologically complex foundation for all later sediments. At the opening of the Cambrian period, then, this region was perhaps a low-lying land mass, with little relief or roughness.

The Cambrian Period

During the first part of the Cambrian period, with which the Paleozoic era began, the condition of the preceding period probably obtained, since there is no evidence in the surrounding area indicative of an early encroachment by the sea. Later in the Cambrian, however, the relative sinking of the land brought it beneath the sea which encroached from the south, and there was deposited a considerable thickness of sandstones and some shales and limestones collectively known to drillers as the "Potsdam sandstone" and here designated "Croixan." Seven hundred feet of deposits of this period are reported in the Hoge log which was given in full in an earlier chapter (p. 105). Records elsewhere show a maximum of about 1,000 feet deposited in this period.

The Ordovician Period

At the close of the Cambrian period, as appears from evidence reported from outside the quadrangle, the area had emerged from the sea, and undergone extensive erosion. But early in the Ordovician period readvance of the sea made possible further deposition, and the very considerable thickness of sandstones, limestones, and shale followed with relatively slight interruption. It is clear from the varied character of these beds that the conditions obtaining were not as uniform during the Ordovician period as during the Cambrian. The Oneota dolomite was followed by the New Richmond sandstone. A return to earlier conditions preceded the deposition of the Shakopee dolomite. From the larger amount of clastic material of Shakopee age east and north of this quadrangle it may be inferred that the land mass which furnished the sediments lay in that direction with the open sea to the south and west.

Evidence from nearby areas indicates that there was a return to land conditions for a time after the deposition of the Shakopee dolomite. This resulted in the development of an uneven erosion surface upon which, during the succeeding submergence, the St. Peter sandstone was deposited. The details of the conditions obtaining are not determined from data gathered in the Morris quadrangle, yet it is evident that the deposition of this widespread blanket of nearly snow-white sand could only take place under unusual conditions. These have been postulated variously by different authors, but it seems probable that the St. Peter sandstone is mainly water-laid rather than eolian sediment although laid down so near shore as to have received much wind-borne sand.

A period of erosion following the deposition of the St. Peter sandstone is suggested by the apparent irregularity of the upper surface of the formation. This is in harmony with the unconformity at the top of this formation at its outcrops in La Salle County. At some time after the deposition of the St. Peter sandstone there appears to have been a slight deformative movement which resulted in a tilting of the surface toward the southeast. The deep burial of the beds prevents demonstration of this movement. The later transgression by the sea brought about conditions favorable for further deposition, and on top of this uneven surface of St. Peter sandstone was laid the Platteville limestone. With but an inconspicuous break in deposition, if any occurred, the Galena formation followed, a massive dolomite several hundred feet thick.

Following the deposition of the Galena dolomite a change in conditions permitted a thinner series of muds to be laid down. These were in part calcareous, and hardened into the shale member of the Maquoketa formation. This change may have involved a recession of the sea or may have been occasioned by shifting in land drainage. The apparently clean-cut break from the dolomite to the shale is in harmony with a land emergence, which may have been slight and brief. Mud deposition continued until enough to produce some 60 or 70 feet of shale had been laid down, and then the introduction of calcareous material began. This resulted in a series of shales with the interbedded lenses of impure limestone, followed by some 50 feet of limestone. The purity of this upper calcareous deposit indicates clear water conditions in contrast with the muddy waters of early Maquoketa time

The proximity of this area to the shore line of the Maquoketa sea is suggested both by the change in depositional conditions and by the variation in shale and lime proportions shown by logs from this and adjoining areas. The greater thickness of limestones and shales to the east in Will County suggests that the sea came in from that direction. There is nothing to indicate, however, that the shore line was within the Morris quadrangle.

The record of deformation during the later Ordovician is scanty. It seems plausible that the several changes in position of the shore line were accompanied by more or less uneven uplift or depression of the area involved.

The postulated uplift along the Coal City axis, involving all pre-Pennsylvanian beds, is the only other important event suggested by the evidence at hand.

The absence of any sediments belonging to the periods between the Ordovician and the Pennsylvanian, leaves the history of this interval somewhat in doubt, yet suggestive relations of rocks to the east may be noted in this connection.

East of the Morris quadrangle the Maquoketa formation is overlain unconformably by Silurian beds of either Alexandrian or Niagaran age. It is apparent that the Alexandrian sea may have covered part or all of the Morris area, and its deposit later been eroded. While no trace of Niagaran beds appears in the Morris region, their presence west of the La Salle fold as well as in the eastern part of the State makes plausible the assumption of transgression by the sea at that time. Except for the complete absence of all deposits later than Maquoketa there is no record of events of post-Ordovician and pre-Pennsylvanian time. We know only that erosion prevailed. From evidence in other parts of northern Illinois, it seems probable that the sea covered the Morris region at least twice during the Silurian and Devonian periods.

The Pennsylvanian Period

With the opening of this period began the last widespread deposition by water in the part of Illinois which includes the area under investigation. Because of the character of the deposits made during this period it is the most important from an economic standpoint. During early Pottsville time, while deposits were being made in the deeper parts of the Eastern Interior Basin, the Morris region continued to be subject to the processes of weathering and erosion. Somewhat later, however, the northward extension of the area of deposition resulted in the formation of a series of sandstones, shales, clays, and thin coals. These reveal shallow water and shore conditions with subordinate marshes supporting abundant vegetation. These latter were of limited areal extent and short lived so that no notable accumulation of peaty matter resulted.

At the time of the deposition of No. 2 coal, a more widespread uniformity of conditions was inaugurated. No. 2 coal itself, while showing some variation in thickness, is essentially uniform throughout not only the Morris quadrangle, but throughout an area which possibly includes much of the Illinois coal field. A distinct change in conditions is thus demonstrated, for the extent of any of the Pottsville sediments is markedly restricted. The marsh conditions, under which No. 2 coal was deposited, were followed by conditions permitting the introduction of mud and sand. In these sediments the cross bedding, lenticular character, and horizontal as well as vertical variation in composition suggests constantly changing conditions. This feature, considered in connection with the aggregation of argillaceous and arenaceous material of varied types implies a continental rather than marine area of deposition.

That the deposition did not continue uninterruptedly is shown by the marked breaks amounting to local unconformities noted in another connection. How widespread these were cannot be determined from present data, which, however, do indicate that considerable portions of the quadrangle at least were involved. The differences in contemporaneous sediments in different parts of the area are indicated by the apparent restriction of the well-known Mazon fossil beds to a small area. While more complete data may show a widespread stratum of this type, the two "fossil beds" exposed were apparently deposited in a limited basin. The lateral gradation from argillaceous to distinctly arenaceous types of material appears clear, and indicates a more or less secluded or sheltered area of deposition of the fine muds comprising the fossiliferous shales. The fossil content of the latter proves their non-marine origin.

For a considerable period after the deposition of No. 2 coal, land conditions obtained as shown by the irregular alternations of sandstone, shaly sandstone, sandy shale, and calcareous clastic beds with thin and locally developed beds of carbonaceous material. In places the last named are true coals, but in few places are they thick enough to attract local prospectors.

Toward the close of the Carbondale epoch, coal-forming conditions existed somewhat generally, and a thin bed, possibly to be correlated as No. 5 coal, was laid down over at least the southwestern quarter of the quadrangle. To what extent this bed originally covered the rest of the quadrangle is not known, but well records indicate that subsequent erosion removed all trace of such beds, if they were ever present, over most of Felix and Goose Lake townships. The data are insufficient to warrant inference on this point from generalizations as to thickness or relation to No. 2 coal.

Whether deposition ceased before the close of Carbondale time, or extended into the McLeansboro can be determined only upon the identification of sediments of the latter age. Present data show an absence of either the limestone marking the basal portion of the McLeansboro beds, or of coals which can certainly be identified as No. 6 or No. 7. The facts at hand can be harmonized easily with the conception of a cessation of sedimentation soon after the deposition of No. 5 coal—the thin upper bed of the Morris area being provisionally so classed—and the subjection of the entire area to weathering and erosion during the remaining pre-glacial time.

The Mesozoic and Cenozoic Eras

Events of Mesozoic and Cenozoic eras apparently did not involve deposition here except during Quaternary time. The drift covering of the area is thick, and the scattered well records do not reveal the pre-glacial topography in sufficient detail to make delineation of erosional changes possible. It is nevertheless clear that just prior to the advent of the ice the relief of the surface was moderate, with the possible exception of the area adjoining the present Illinois Valley. (See fig. 33.) Here the greater relief of the bed rock surface may have resulted from erosion in Pleistocene time, and hence not indicate extensive pre-glacial trenching. From the apparent development of short tributary valleys cut in bed rock, it may be inferred that a late Tertiary uplift had rejuvenated the streams working over an area peneplaned in post-Paleozoic time.

THE PLEISTOCENE PERIOD

The early events of the Pleistocene period have been worked out from data gathered from many parts of the North American continent. This history shows that during this time there were at least five distinct ice invasions, separated by very long interglacial stages. Beginning with the oldest, the glacial stages have been called the Nebraskan, the Kansan, the Illinoian, the Iowan, and the Wisconsin (p. 147). There is no positive record of the Nebraskan or of the Kansan invasions in this part of Illinois, although certain deposits of old till found in Bureau County have been referred to a pre-Illinoian stage by Cady,[24] who also has recognized Illinoian till in the same region. While no deposits clearly of Illinoian age have been found in the Morris quadrangle, its geographic position with reference to the area known to have been glaciated at that time is such that there is no doubt that the Illinoian ice-sheet covered this area.

There is no evidence indicating that ice covered the Morris region during the succeeding Iowan invasion, but there is abundant evidence that the region was almost continually beneath the ice until after the Marseilles stage of the Wisconsin epoch.

During the Wisconsin epoch it is believed that the ice front oscillated repeatedly, but that at times it was essentially stationary long enough to permit the accumulation of great belts of till and associated deposits at and under its edge. These ridges, or terminal moraines, dominate the topography in many parts of the State, and include the ridges known as the Shelbyville, Bloomington, Marseilles, Minooka, Valparaiso and Lake Border moraines, respectively.

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[24] Cady, G. H., Geology and mineral resources of the Hennepin and La Salle quadrangles: Ill. State Geol. Survey Bull. 37, p. 70, 1919.

The history of only the latter part of the Pleistocene period is recorded within the Morris area. It is clear that the region was overwhelmed by continental ice sheets earlier than the local depositional record suggests. It was probably covered by deposits of glacial origin during the Illinoian invasion as well as during the early advances of the Wisconsin ice, but if so, most of the deposited material, and presumably some of the bed rock as well, was removed during the succeeding interglacial stage or the following ice invasion. The presence of glacial striæ on the bed rock surface trending about S. 50° W. (Pl. II) indicates erosion by ice in pre-Marseilles time since the trend of the terminal ridge of that time indicates westward-moving ice. So few such surfaces are observable, however, that the reference of the striæ to a certain invasion is not feasible.

The till and associated deposits comprising the surface of this area were spread out during the latter part of the Wisconsin epoch. It is probable that the ice which formed the Bloomington moraine and is known to have made deposits of considerable extent and thickness in the area west of the Morris quadrangle also left more or less debris in the latter region. After the recession of the ice of the Bloomington stage, a lake was formed over the area between Morris and Seneca. In this lake were deposited the laminated clays found at various points between these places and utilized for tile manufacture at Morris. The altitude of the clays shows that the level of this lake was above 530 feet. The beds may be referable to a 600-foot lake postulated by Leighton on evidence noted farther down the valley, but the identity of these two lakes is not demonstrated.[25] The areal extent of this lake is problematical. To the west, no limit can be set from data gathered within this quadrangle. To the east, the Morris basin must have been inundated as far as the recession of the Bloomington ice permitted until a large part of the quadrangle was under water. The lake boundary at the south, east or north may have been considerably outside the limits of the Morris area,[26] while on the west the Bloomington morainic ridge limited the spreading waters.

THE MARSEILLES STAGE

The advent of the Marseilles ice must have eliminated the eastern portion of the lake east of the Marseilles morainic ridge, which apparently marks the western limit of the next ice advance and forms the west boundary of the Morris Basin. At the time of the formation of this moraine the ice front stood at the position of this elevated area and the waters from the ice found their way westward presumably down the Fox and Illinois valleys. During this period Morris Basin probably was somewhat aggraded by the ice, as there would be little erosive action so near the ice front.

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[25] Unpublished notes.

[26] Recent work by Dr. D. J. Fisher, of the Illinois State Geological Survey has shown the presence of lake sands and laminated clays referable to this lake in the Des Plaines valley.

With the retreat of the ice front to a position slightly behind the crest of the Marseilles moraine there must have been developed a series of ponds between the moraine and the ice. These would fill until an outlet was found, through which the overflow would escape in a series of separate streams. With continued ice recession the ponds would develop into proglacial lakes dammed by the moraine on the west and the ice on the east.

The early water level of these lakes probably was more than 700 feet above the sea, but it is unlikely that this level was long maintained. Erosion at the outlets lowered the water level and slightly reduced the area submerged. On the other hand the recession of the ice eastward would have uncovered relatively flat land and may have greatly increased the area flooded. By the time the ice front had reached the west side of the Morris quadrangle the outlet across the morainic dam probably had been cut down to about 600 feet.

There is little evidence to show that the ice front did not retreat at a regular rate across the Morris Basin. Had it remained stationary for any considerable period of time a deposit similar in character to the Marseilles moraine would have been formed, and its size would have been related to the time involved. Such deposit is found near the west limit of the quadrangle, where a line of low ridges, locally little more than knolls, trends northeastward across the middle of Nettle Creek Township (T. 34 N., R. 6 E.), continuing as far as Central.

There is no evidence to indicate that after this halt the ice did not gradually retreat to the east, at least as far as the vicinity of Minooka ridge.

While the events previously noted were taking place, similar conditions obtained south of the river. The lesser height of the main morainic ridge to the west precluded the presence of any ponds above the 700-foot level, and indeed the area in which a lake of even that level could have been maintained is small. Below that level, as at 680 and 660 feet, there are wide flats, but the absence of higher limiting areas makes problematical the presence of any lakes in this region comparable in size or level with those to the north.

It is probable that during its recession the ice front would show progressively a more regular outline in its larger features while possibly minor irregularities would be increased. Thus the projection of the ice occupying the site of the present Illinois valley would be eliminated gradually, the front developing a rounded outline only roughly parallel to the Marseilles moraine. By the time the ice had retreated as far as Seneca it is probable that the waters from north and south were uniting to form the early Illinois River. At this time the level of the outlet may have been held by the morainic dam above 600 feet, perhaps as high as 640, and in that case a wide river, shallow and of low gradient may be postulated. This water may have been a lake rather than a river, but a long sinuous shape seems necessarily to have resulted from the topography of the area. The precise boundary of this body of water is not here defined.

With the further retreat of the ice there was exposed a much larger area which would have been covered by the 640-foot water. Whether it was covered or not depended largely upon the relation between the rate of retreat of the ice front and that of the downcutting at the outlet. After the union of waters north and south of the river, the erosion of the single valley across the moraine must have proceeded with relative rapidity. No evidence has been found indicative of the area covered by the 640-foot water, nor indeed at any level above 600 feet. Hence present data lead to the conclusion that the outlet across the Marseilles moraine, if at any time higher than the pre-Marseilles level, 600 feet, was reduced to that level shortly after the withdrawal of the ice of the Marseilles stage.

That a body of water existed at the latter level, in post-Marseilles time, is indicated by the presence of a gravel and sand deposit in the southeast quarter of section 8, Erienna Township (T. 33 N., R. 7 E.), south of Long Point school (Pl. III*A*). A similar deposit was observed by Leighton about a mile to the northwest. These consist of well-assorted gravels and sands exhibiting delta bedding. The upper surfaces lie between 600 and 620 feet above sea level and may be interpreted as deposits made at the mouths of streams entering a lake at that level.

The fact that a lake at approximately this level was in existence prior to the advent of the Marseilles ice, as noted above (p. 174), leads to the inference that after the dam of morainic material at Marseilles had been eroded to the 600-foot level, the same obstacle to further erosion of this valley which had been operative in pre-Marseilles time, again became the controlling factor with the result that a lake was again maintained at that level.

The duration of this lake through any considerable period would have resulted in the production of the usual depositional and erosional shore features of such bodies of water. The absence of these features is good negative evidence of the relatively early lowering of the lake level. However, the drainage pattern of Nettle Creek suggests that the upstream part

antedates the downstream part. There is a much better development of tributary valleys and ravines above than below the 600-foot level.[27] This is the normal relation if the mouth of the stream was lowered after having been at the 600-foot level for some time, and substantiates the assumption of a 600-foot lake.

There is nothing in the topography of the region to indicate that after the lowering of this 600-foot lake there was not a regular withdrawal of the ice to the east, and a nearly equally regular lowering of the level of the water by erosion of the outlet channel.

The shape of the ice-front during the recession of the ice sheet was at all times an important factor in the disposition of the lines of drainage, ponds and associated deposits. The position of the ice during the early stages of its retreat can be read from the topography today, but later erosion of the valleys of the Illinois, Des Plaines and Kankakee rivers has removed a large part of the glacial deposits east of Morris, and consequently the exact outline of the ice-front at any given time is problematical. For example, no evidence has been secured which indicates the position of the ice-front—which was probably the eastern limit of the water—at the time the 600-foot lake existed.

Between that stage and the time of removal of the ice from the south half of the quadrangle, there is no trace of the succeeding positions of the front. North of the river there is a suggestion in the elongate ridges along Aux Sable Creek that the ice was stationary for a time along that line. Sand and gravel appear in the N. E. ¼ of section 9, Aux Sable Township (T. 34 N., R. 8 E.), where they lie on the west slope of a ridge and were apparently deposited at the edge of the ice. Whether this occurred during the retreat of the Marseilles ice or at the time of the formation of Minooka Ridge is not determined.

From the valley of Aux Sable Creek eastward, all trace of the deposits of the Marseilles ice is obliterated by the younger Minooka till. The extent of the retreat of the Marseilles ice prior to the formation of this deposit is not known. It seems probable that land as far east as Joliet was uncovered, although the recession of the ice east of the head of the Illinois is not demonstrated.

THE MINOOKA STAGE

Apparently the next important event, following the recession of the Marseilles ice across the Morris Basin, was the formation of Minooka Ridge, which, rising prominently above the basin, marks its northeastern margin. The time elapsing between these two events can be determined in the broadest terms only. As compared with the other interglacial stages of Wisconsin time, it probably was of short duration. As pointing to this conclusion, there is no indication of the development of an interglacial soil. Indeed, the distinction between the two tills is by no means clear in some places.

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[27] The upstream portion is shown on the map of the Marseilles Quadrangle.

Throughout the Minooka stage there was maintained in the Morris Basin the lake which was formed after the recession of the Marseilles ice. When the Minooka ice began its retreat there ensued a series of events of the same general type as those noted for the Marseilles stage. At first, waters flowed across Minooka Ridge in sec. 13, T. 36 N., R 8. E., as noted by Leverett.[28] These waters must have followed the Aux Sable Valley to the edge of the lake occupying the Morris Basin. To what extent the waters from the receding Minooka ice overflowed to the southwest and south can not be told from present topography since all trace of any such drainage, if it existed, has been removed by subsequent erosion. With the details of this retreat and of the events during the succeeding Valparaiso stage of the ice in the region northeast of Joliet the present report is concerned only in so far as these events determined processes and results down the valley to the west.

The Lake Morris sub-stage. At some time after the withdrawal of the Marseilles ice and probably before the formation of the Valparaiso moraine the level of the lake in Morris Basin was lowered from 600 to 560 feet. As already stated, it seems probable that this lowering took place soon after the withdrawal of the Marseilles ice. The absence of outwash from the Minooka till ridge in the nature of delta deposits referable to the 600-foot stage substantiates this view. As in the case of the 600-foot lake, the site of the obstruction for the 560-foot water lies west of the Morris quadrangle. It is clear that the downcutting of the outlet would progress rapidly until bed rock beneath the till was reached. The presence of Pennsylvanian strata in the valley walls near Marseilles up to about 560 feet[29] may have been the cause of the maintenance of a lake at that level in the Morris Basin. Any extension of the lake west of the site of Morris must have been little more than a widened river, since the 560-foot contour lines converge sharply there.

Suggestion that the water level was maintained at about 560 feet for a much longer time than at any higher level in the Morris Basin is found in the more abundant evidence of its existence at that level. Not only does the drainage pattern of Morris Basin suggest such a lake but there are numerous deposits which by their character, disposition and elevation practically fix the limits of this body of water (Pl. III*A*). For convenience of discussion, this lake of post-Marseilles age, which filled the Morris Basin up to about the 560-foot level, covering an area of some 150 square miles, is named *Lake Morris*.

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[28] Leverett, Frank, The Illinois glacial lobe: U. S. Geol. Survey Mon. 38, p. 319, 1899.

[29] Cady, G. H., Field notes on Ottawa-Marseilles quadrangles.

North of the Illinois the evidence of this lake is meager. Isolated, inconspicuous sandy patches, such as that transverse to Nettle Creek in section 20 of Saratoga Township (T. 34 N., R. 7 E.), suggest a beach, but the exact area occupied by the water at this level is problematical. There is little reason to believe that the topography has been subsequently modified to a greater degree here than on the south, or that the surface has been deformed, and it is assumed that the 560-foot contour line marks the approximate extent of the lake waters.

The Aux Sable Valley must have been in large part covered by waters of Lake Morris. Although the topography of the valley suggests some aggrading prior to the recent erosion by the Aux Sable, it is not evident that any vigorous erosion was taking place on the west slope of Minooka Ridge.

In case the valley of the Aux Sable was inundated, the low till ridges and hills north of Sand Ridge were islands. Their topography is fresh, morainic, and little modified by stream action. Any shore features that may have been developed along the southern margin of Minooka Ridge have been obliterated by subsequent erosion.

The lack of a beach on the north side of the lake, contrasted with the marked beach ridge on the southeast, points to certain controlling conditions. Accumulations of beach material could be derived only by the reworking of a large amount of till. Such sorting is normally performed by rivers traversing the area or by waves and undertow at the beach. On the north, only a limited area was drained by tributaries to Lake Morris, and this region was smooth and of slight relief. In the short time between the retreat of the Marseilles ice and the lowering of the lake level no systematic drainage developed, and hence the region could not have been subjected to vigorous stream action. Under these conditions little material was brought to the shore for the building of a beach. Furthermore, in view of the long gentle slope of the lake bottom, the short life of the lake itself precluded the chance of enough shoreward cutting to supply material to make a beach comparable with that found elsewhere. To the south and east, however, conditions were radically different and were favorable to the development of beaches of distinctive size. From the southeast along the margin of the ice came the flooded Kankakee, overloaded with debris from the glacier.

This stream brought great quantities of fine gravel, sand and silt to the lake and from them the prominent beach could be formed. Under these conditions, a silt filling of some consequence might be expected in this region, and evidence of such deposition is found in auger borings on the pronounced flat north of Coal City and west of Wilmington. Kankakee River at this time was aggrading its channel, and by the close of the stage of the 560-foot lake, probably had filled the valley in the vicinity of Ritchey to the 560-foot level, possibly as high as 570 feet, as indicated by the gravel deposits remaining there. The valley here is about two miles wide, so that a considerable filling is suggested.

Downstream, to the north, the finer gravel and sand were deposited in great quantity and were spread over a wider area by the stream, which, on reaching the gentler slopes of the lake shore, was heavily overloaded. The absence of shore features across the sand flat may be ascribed to the continued introduction of sand during and even later than the life of the lake.

Conditions on the east side of Lake Morris were essentially the same as along the southeast shore. On both sides of Prairie Creek, section 12, Wilmington Township (T. 33 N., R. 9 E.), Will County, are low ridges of sand and gravel, suggestive of beaches.

A similar deposit lies along Grant Creek, north of which a thick gravel deposit slightly above the 560-foot level shows clearly the entrance to the lake of a heavily laden stream from the north. Northwest of this deposit, east of Channahon, similar deposits indicate valley filling entirely across the gap between Minooka Ridge and the similar till surface more than four miles to the east.

In its early stages, the valley-filling of the Des Plaines was in the nature of valley-train deposition, including slightly inclined beds, with current bedding prominent. With further retreat of the ice the development of a lower gradient resulted.

That the above noted heavy gravel deposits of the Des Plaines Valley are outwash from the Valparaiso glacier was shown by Leverett,[30] who further suggested that the abrupt termination of the gravels near Channahon was due to the presence of a lake in the Morris Basin.

Just as the history of the Morris Basin thus far outlined is closely tied to events in the glacial history of the area immediately to the northeast, so in the later stages of its history the controlling conditions are found to be in the Lake Michigan Basin.

Following the Valparaiso stage of glaciation came the Lake Border stage, when the ice extended little farther than the Lake Michigan depression. Its waters, however, continued to flow down the Des Plaines and Illinois valleys.

The Cryder Lake sub-stage.—The downcutting at the outlet must have continued during the Lake Morris sub-stage, but when the 540-foot level was reached another halt in the lowering of the lake was made and beach lines marking the edge of the water were formed. To this body of water the name *Cryder Lake* is given, from Cryder school, which is located on the beach line, where it is well developed and preserved. A possible cause for this halt in the lowering of the lake is the presence of a resistant sandstone in the valley walls near Marseilles up to at least the 540-foot level. The fact that this standstone, the Waupecan, is overlain by soft shales leads to the inference that this was a factor of considerable importance in the rate of downcutting.

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[30] Leverett, Frank, The Illinois glacial lobe: U. S. Geol. Survey Mon. 38, pp. 377-8, 1899.

Cryder Lake existed for some time in the Morris Basin, as attested by the good beach still in evidence. A beach line at this level may be traced almost entirely around the depression (Pl. III*A*). It has its best development north of Morris, where it is in part utilized as the site of Ridge Road, leading northeast. It can be followed along Sand Ridge, and thence southeast to the steep bluff at the head of Illinois River, where later erosion has eliminated all trace of it. East of this point it can be observed in several places on the lowland north of Wilmington, and traced westward, on the south side, it apparently is coincident with the heavy dune sand of Sand Ridge, three miles north of Coal City. West of Mazon River it is again distinct as far as Waupecan Creek, where the narrowed valley precludes the possibility of its having been retained, if ever formed.

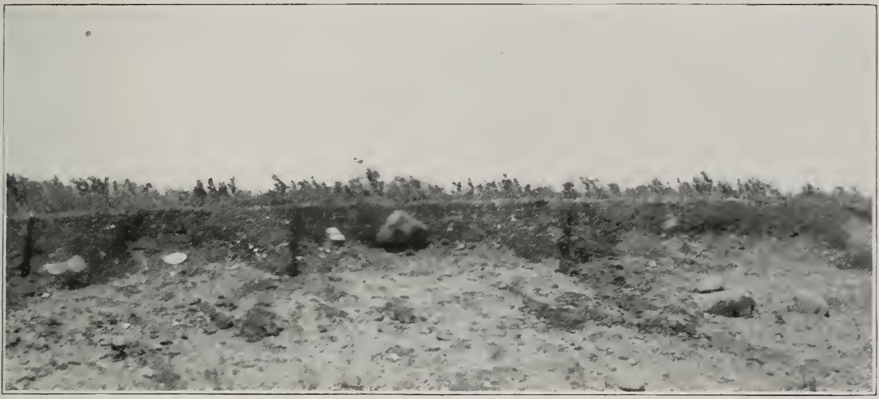

Fig. 39. Gravel deposit in sec. 21, Wauponsee Twp. The larger rocks probably have been transported by floating ice which lodged on the beach. The diameter of the largest boulder shown is about 18 inches

That portion of the beach lying in section 20 of Wauponsee Township (T. 33 N., R. 7 E.) presents certain anomalous features which appear to demand peculiar controlling conditions in that area. Here the beach ridge is surmounted by, if it does not contain throughout, large boulders of igneous and metamorphic rocks. The absence of limestone which characterizes the adjacent till suggests a more distant source for this coarse material. The prominence of the boulders gradually disappears along the beach to the east (fig. 39), thus pointing to a localization of the controlling factors. Transportation of the boulders by floating ice which was stranded on this part of the beach seems to be the logical explanation for their concentration here. Similar boulder deposits south of the beach may have been made when the water level was higher.

Most of the area bounded by the beach shows some evidence of having been covered by a body of standing water. The elongate ridge about two miles west of Morris, however, shows no trace of having been inundated at that time. Its crest is a few feet above 540, and hence may have been slightly above the highest level of Cryder Lake. The presence of gravel and sand on the western end of this ridge at the same level as the beach lines north and south of the Illinois makes such an assumption valid.

It is clear that drainage conditions obtaining during this stage were different from those of the preceding stage. The body of water outlined by the beach remnants was little more than half as large as Lake Morris.

The absence of any extensive deposits comparable to those made in Lake Morris suggests that the water of Cryder Lake was able to transport most of the sand and silt brought to it. The character of the marginal slope and of the bottom of the basin is in harmony with this conception and leads to the inference that Cryder Lake was little more than a widened river whose high level is represented by the 540-foot contour line.

It is not improbable that there was deposition of limited amounts of sand over most of the basin of Cryder Lake during the early part of this stage, the finer sediment being carried downstream. Maximum deposits would have been made at the mouths of streams entering this lake, especially at the mouth of the Chicago outlet in the DesPlaines Valley east of the Morris quadrangle. There are terrace deposits along Waupecan Creek and Mazon River, as well as the smaller tributaries which probably were contemporaneous with Cryder Lake.

The further lowering of the outlet of Cryder Lake ultimately resulted in draining it. While this was taking place no further beach would have been formed, and the 540-foot beach would have been incised by tributary streams. Topographically, the result was a transformation of the old lake bottom into an erosion surface about 15 feet below the beach with a relatively abrupt slope up to it. Channel scars mark the position of the later channels in the wide river bottom. The lack of uniformity in the altitude of this wide flat is obviously related to the unevenness of the bed rock surface, which is exposed in places.

As indicating substages in this development, are to be noted the remnants of terraces below the 540-foot level along such streams as Nettle and Waupecan creeks. Further downcutting of this part of the Illinois Valley was restricted to a relatively narrow strip approximately bisecting the Cryder

Lake basin. Evidence as to the work done by this early river is concealed, if not entirely eliminated through the deposition by the stream of the next stage.

LATER HISTORY OF THE ILLINOIS VALLEY

At some period after the draining of Cryder Lake the present Illinois Valley was filled to overflowing by a much more powerful stream than that immediately succeeding the Cryder Lake stage. The further lowering of the outlet, however, may have caused its restriction to the narrow channel which it maintained. This stream not only transported great volumes of sand and coarse gravels from the DesPlaines gravel beds above Channahon but also was apparently able to scour the previously existing channel. It seems to have maintained a wide but shallow channel in its course over the exposed rocks above and just below the head of Illinois River. It is not impossible that these knolls of limestone and sandstone remained as islands in the streams most of the time, while the circuitous channels outlined by the gravel deposits of this stage were incised. (See Plate II.) Downstream, however, the relative weakness of the Carbondale formation permitted deeper and more concentrated erosion. The bed rock conditions east of Morris are such as might readily have caused the development of prominent rapids in the postulated stream as it passed from the resistant Pottsville to the weaker Carbondale strata. It appears probable that at the stage of maximum volume, waters were ponded in the shallow depressions adjoining the main channel of this date, and that under these conditions were deposited the sand, marl and peat beds in the area just north of Morris revealed in Bell's stripping pit in sec. 34, T. 34 N., R. 7 E. The great volume of the stream is attested by the depth of the erosion as well as by the amount and character of the deposits, but more clearly still by the low gradient which it appears to have maintained. By the time this powerful stream was somewhat reduced the pre-existing surface had been incised to a maximum depth of perhaps 35 feet. With further reduction of volume, not only this channel but the adjacent less eroded lowlands were concealed by deposits of sand and gravel. It was at this time that the prominent gravel and sand deposits at the 520-foot level bordering the flood plain of the present Illinois were laid down. The undulatory character of the surface and the "pockety" nature of the gravel and sand beds reveal their origin in sand and gravel bars in the bed of this ancient river. With the further reduction of its volume, maximum deposition by this stream was made farther and farther upstream above the head of Illinois River.

The next step in the development of the topography of the Morris Basin was the restriction of the active stream to the relatively narrow channel which it occupies now. Coincident with this was an increase in erosive power which resulted in the development of a shallow trench within the sand and gravel flat. A temporary increase in volume is the most probable cause of this incision. This was followed by a reduction in volume and consequent deposition within the trench and at this time the present stage in the history of the Illinois opened. With the later development of the tributaries in the headwater areas, the amount of water coming down the Kankakee and the DesPlaines has been increased gradually. Corresponding to this change there has been more and more transportation of material. Only the fine sand and silt from the drainage area is being brought down, however, and the development of the rich flood plain lands bordering the Illinois in the Morris quadrangle has resulted. That this alluvial filling is only a thin coating over the gravels of the preceding stage is evident from all pits and borings made over the flood plain.

CHAPTER VI—ECONOMIC GEOLOGY

The foregoing discussion of the various geologic features of the Morris quadrangle serves as the basis for a description of the economic resources of the region. Without such basis the discussion of mineral wealth can be little more than a catalog of known resources without reference to their vertical and areal extent and without guidance for further exploration. With their relations revealed by a study of the stratigraphy, however, the restriction of coal, limestone, sand and gravel to certain areas is clear, and the size and shape of known bodies of useful materials as well as the probable character of similar material yet undiscovered may be fairly estimated.

Coal, shale and clay, stone, sand and gravel, as well as water and soils, comprise the known resources, which will be discussed in the order given. Brief reference will be made also to the possibility of finding oil in the area, although oil is not known at the present time to exist here in commercial quantity.

Coal

GENERAL RELATIONS

The Morris quadrangle lies at the northeast edge of the Eastern Interior Coal Basin, the great coal field which includes most of Illinois and parts of states adjoining on the east, south and west. Disregarding the commercially unimportant outliers of this portion of the field, the border of the basin crosses the quadrangle in an irregular line trending northwest-southeast a few miles northeast of the town of Morris. The entire quadrangle southwest of this line is probably underlain by one or more beds of workable coal.

That portion of the quadrangle underlain by No. 2 coal in commercial thickness is included in what is known as the Longwall District, a subdivision of the coal fields of Illinois and given that designation from the prevailing method of mining. This district includes part or all of Bureau, Putnam, Marshall, La Salle, Livingston, Grundy, Will and Kankakee counties.

The only coal of the area commercially important at the present time is No. 2 bed, which outcrops just northeast of Morris and underlies the southwestern part of the quadrangle. This coal marks the base of the Carbondale formation and hence has stratigraphic as well as economic importance. Thin coals are known, both from outcrop and exploration, above and below No. 2, but none so far discovered warrants development.

POTTSVILLE COALS

The coals of the Pottsville series have not been widely explored, but such openings on them as have been made indicate that there are carbonaceous beds at several horizons. These show varied development, in places being merely a thin streak of carbonaceous material while elsewhere several feet of coal may appear (fig. 24).

As noted in the discussion of the stratigraphy of the region, the coal uncovered in stripping for the clay pit at the west end of Goose Lake is considered to be a bed lying below No. 2 coal. The details of this section were included in the earlier discussion (p. 136). This, or a similar bed, was opened as a country bank a few rods southeast of the pit many years ago and essentially the same section was reported. It is probable that the full thickness of the coal bed is somewhat greater than the section shows, although no openings to the south, down the dip, have been made. Further development may reveal not only a greater thickness of coal, but the presence of roof shales as well. Plant fossils in these shales may render the exact correlation of this coal possible.

The bed of coal worked in the two shafts in section 19 of Aux Sable Township (T. 34 N., R. 8 E.) apparently has the same stratigraphic position as the Goose Lake coal. It was 28 inches thick, with variable roof and had only a limited extent. Bradley did not consider the evidence sufficiently clear to permit correlation.[31] No other openings are known to have been made on Pottsville coals, nor were these of more than local importance. Such beds have been reported in some borings, as in the case of the well at Braidwood[32] just east of the Morris quadrangle, where three coals were encountered in the 60 feet of Pottsville sediments. There is no indication that the coals below No. 2 have any better development south of the edge of the Pennsylvanian basin than where they have been encountered.

Carbondale Coals

NO. 2 COAL

This bed is widespread, of remarkably uniform thickness and character and has been mined in scores of openings. The presence of this coal in workable thickness, is the basis for delimiting the Longwall District in this State. It underlies all of the quadrangle south of its outcrop except possibly the valley of the Illinois above Morris. While the heavy drift cover prevents exact delineation of the outcrop, its approximate location is shown on Plate III, thus indicating the contact of Pottsville and Carbondale formations.

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[31] Bradley, Frank H., Geol. of Ill., Vol. IV, p. 198, 1870.

[32] Log furnished by Mr. William Campbell of Coal City.

As thus mapped about 115 square miles are underlain by the Carbondale formation. In the estimate of available tonnage from No. 2 coal in this region there must be considered (1) the variation in thickness of the bed, (2) the area which is unworkable by shaft mining because of poor roof and (3) the area already mined out. The lack of reliable data on these points renders more than a rough approximation of the tonnage impracticable.

While there are few borings penetrating No. 2 coal in that part of the quadrangle lying west of Mazon River, the uniformity in thickness of the bed in the vicinity of Coal City and in the region south of Seneca leads to the inference that No. 2 is present in average thickness in the intervening area. That part of the bed which is overlain by a poor roof is probably restricted to a strip parallel to the outcrop, and approximately two miles wide. This would eliminate between thirty and forty square miles from the field available for shaft mining. It is probable that a considerable portion of this tonnage is recoverable, however, by stripping operations, which thus compensate, or partly compensate, for the assumed loss.

Figures for the total production of this area are in error by an unknown percentage and in any case serve only as a guide in this estimate, since for every ton of coal reported as mined it is probable that approximately a half a ton has been rendered unfit for mining. Estimate of this factor by calculation of the area involved in operations of the known mines gives a figure of about twenty square miles. From the original estimate of 115 square miles there is thus to be deducted about fifty square miles. Assuming an average thickness of 30 inches, the remaining sixty-five square miles contain about 183,000,000 tons.

Physical character.—No. 2 bed is characterized by the alternation of dull and bright bands of clean coal without persistent bands of impurities. Thin plates of calcite commonly are seen on vertical faces. Pyritic lenses, "bone" or shale bands and charcoal or mining dirt separate the clean coal bands, but these impurities are small in amount and so irregularly disposed that the bed as a whole shows no benches. The pyritic impurities, such as "sulphur balls," are not readily separated from the coal and hence some coal is lost in separating the pyrite. In the deeper openings the coal is relatively hard and brittle, the top coal being harder than the bottom and in most places of brighter luster. "Cleat" is nowhere well developed. In the shallower workings the coal is relatively soft and shows less difference in hardness and texture between top and bottom.

Chemical composition.—The chemical character of No. 2 coal is fairly well established for the Morris region, although but few samples from the openings within the quadrangle have been analyzed. The average for Grundy County shows a high moisture content with medium sulphur and low ash. Determinations of heating value show an average of almost 11,000 B. t. u. on the "as received" basis.

In the appended list are presented all the available analyses of No. 2 coal from the Morris quadrangle. These were made for the State Geological Survey under the direction of Professor S. W. Parr.

TABLE 6—*Proximate analyses of No. 2 coal from Morris Quadrangle*

Laboratory No.	Form[a] of Analysis	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	Carbon as CO_2	British thermal units
2624	A	17.56	35.63	36.19	10.62	1.70	....	10200
	B	....	43.22	43.90	12.88	2.06	....	12373
5367	A	19.97	38.16	37.45	4.42	1.82	.65	10936
	B	....	47.68	46.79	5.53	2.27	.79	13664
5368	A	18.95	37.60	38.23	5.22	2.46	.64	10787
	B	......	46.39	47.16	6.45	3.04	.79	13309
5369	A	19.66	37.01	38.16	5.17	2.03	.83	10734
	B	....	46.06	47.50	6.44	2.53	1.03	13360
2609	A	13.24	36.44	39.04	11.28	5.42	....	10764
	B	....	42.00	44.99	13.01	6.24	....	12406
734	A	14.16	....	....	5.00	1.57	....	11531
	B	....	....	....	5.82	1.83	....	13436
4391	A	16.43	36.64	41.25	5.68	2.36	....	11089
	B	....	43.84	49.37	6.79	2.83	....	13269
4392	A	14.50	38.62	41.12	5.76	2.27	.40	11196
	B	....	45.17	48.10	6.73	2.66	.47	13095
5373	A	17.29	38.61	36.69	7.41	2.87	1.44	10708
	B	....	46.68	44.36	8.96	3.47	1.74	12947
5374	A	13.73	39.87	42.19	4.21	2.04	1.47	11787
	B	....	46.22	48.90	4.88	2.37	1.71	13662
5377	A	17.01	39.48	36.74	6.77	3.32	1.05	10834
	B	....	47.57	44.27	8.16	4.00	1.27	13055

[a] A—"As received"; B—"Moisture free."

The bed varies in thickness from 20 to 72 inches, but shows much greater uniformity than those figures indicate, a variation of less than 5 inches throughout a mine being common. Overlying the coal is gray shale, commonly 40 feet thick, in places so sandy as to be better described as a shaly sandstone. In the No. 3 mine of the Big Four Wilmington Coal Company a relatively pure sandstone overlies the coal in parts of the mine, the more usual shale or "soapstone" coming in as a feather edge between the sandstone and coal, and reaching considerable thickness in places. The floor is characteristically gray clay, plastic when wet and possessing some refractory properties. It is an ideal stratum in which to undercut the coal and is so utilized in most workings. It is invariably called "fire clay," although its lithologic variation undoubtedly indicates equal variation in fire-resisting properties. This clay is rather uniform in thickness in a given mine, but varies from a few inches to more than 5 feet over the district. Below it is a somewhat gritty shale similar to the soapstone above the coal. In the mine of the Braidwood Wilmington Manufacturing Company the 5 or 6 inches of floor clay is underlain in places by 2 to 3 inches of coal with about 4 feet of clay below. Elsewhere the usual succession obtains.

The following descriptions of the bed have been compiled from notes by various members of the Survey:

BIG FOUR WILMINGTON COAL COMPANY, NO. 3, DEWEY SLOPE (A, fig. 40)

Main northwest 1500 feet from shaft. Roof sandstone or shale. The coal is 36 inches thick, contains sulphur balls and is very wet, especially when first opened up. Floor is fire clay.

BRAIDWOOD WILMINGTON MANUFACTURING COMPANY. SHAFT MINE. (B, fig. 40)

Main north 300 feet from shaft. Roof is a hard soapstone and makes a good longwall cover. The coal is 36½ inches thick and is rather wet. The floor is fire clay with 2 to 3 inches of coal about 5 inches below the top. Where the upper clay band is thick enough it is mined and the coal wedged down. The floor is reported to heave a good deal.

CLAYTON BROTHERS. MORRIS. LOCAL SHAFT. (C, fig. 40)

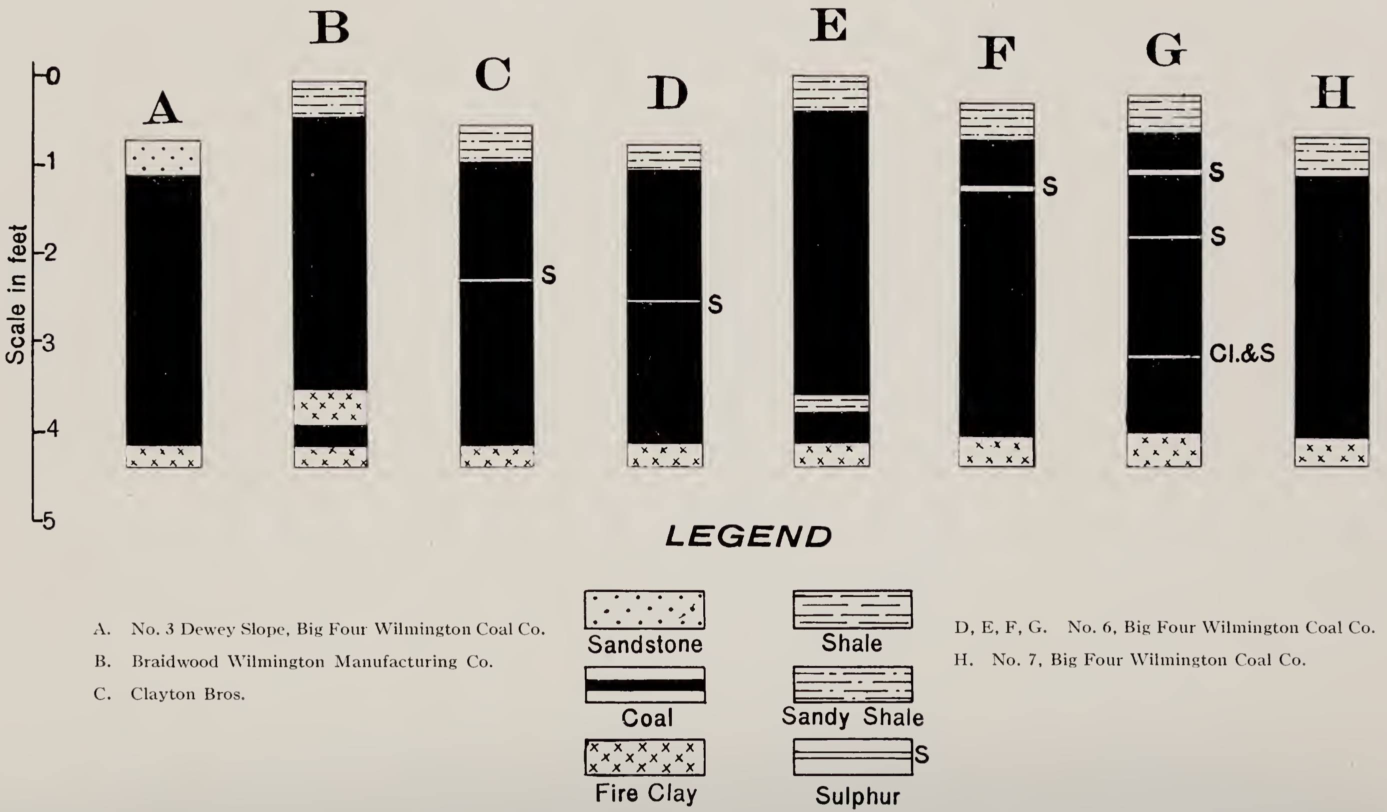
Face of northeast entry. Roof is soapstone. The coal is 38 inches thick with a local band of sulphur and coal ½ inch thick 15 inches from the top. The coal is hackly in fracture and brittle in texture. Floor is fire clay.

WILMINGTON STAR MINING COMPANY. No. 6 (D, E, F, G, fig. 40)

Face southwest entry. Roof gray shale with a black clay at base in places. The coal is 41 inches thick with a total of 3 inches of sulphur and clay in three bands. The 5-inch band of coal is bright while the lower part is duller. The coal shows a hackly appearance on the whole, is solid, brittle, and has no continuous impurities. Floor is fire clay.

WILMINGTON STAR COAL COMPANY, MINE NO. 7, COAL CITY (H, fig. 40)

Face northwest, south entry—roof soapstone. Coal hard and brittle, the top coal harder than the bottom and in most places brighter. Cleat poorly and irregularly developed. The coal shoots into good-sized blocks. There is very little calcite present; near the middle of the bed in parts of the mine there is a band of mother coal and sulphur. The floor is fire clay averaging about 7 feet in thickness. Undercutting is done in the clay to a depth of 18 to 24 inches. Shale is reported to underlie the clay.



A. No. 3 Dewey Slope, Big Four Wilmington Coal Co.
B. Braidwood Wilmington Manufacturing Co.
C. Clayton Bros.
D, E, F, G. No. 6, Big Four Wilmington Coal Co.
H. No. 7, Big Four Wilmington Coal Co.

Fig. 40. Graphic sections of No. 2 seam, Morris Quadrangle

BELL SHAFT. MORRIS. LOCAL

Roof is soapstone with 1 to 5 inches of clod at the base. The contact with the coal is somewhat uneven. The bed is 42 to 48 inches thick and contains sulphur lenses and some shaly bands. The coal is soft, of dull luster, brittle and showing roughly cubic fracture. The floor is a gray fire clay, with plant impressions, but a dark gray "slate" is met locally where it cuts out part of the coal.

HEATHER SHAFT. MORRIS. LOCAL.

Roof is soapstone with 6 to 30 inches of gray shale or "clod" just above the coal. The contact with the coal bed is even. The coal is 30 to 36 inches thick without partings. Soft "brown sulphur" lenses occur about 6 inches from the top of the seam. Floor is a gray clay, which makes undercutting easy.

MITCHELL SHAFT. MORRIS. LOCAL.

Roof is soapstone 27 feet thick. Contact with coal even. The bed is 24 to 34 inches thick, average 30 inches. The coal is brittle and mainly of dull luster. "Sulphur balls" are irregularly distributed but are not abundant. Floor is a fire clay.

While on the whole the continuity of No. 2 coal is noteworthy, there are some marked deviations that are of interest from the scientific as well as the economic aspect. The prominent "roll" encountered in No. 7 mine of the Wilmington Star Mining Company west of Coal City has already been noted. This was described and figured in an earlier report[33] on this region and need not be re-described here. Less prominent "rolls" are met in most mining operations. Some of these appear to be original irregularities in the surface of the swamp in which vegetable matter accumulated. Others are clearly due to intraformational erosion which has in places removed the overlying soapstone and even the upper part of the coal bed, the gap being later filled commonly by crossbedded sandstone. These irregularities always interfere, often seriously, with mining operations. Dislocations of the beds, known to the geologist as faults, are not rare, but are of such dimensions that they have no commercial significance.

COAL BEDS ABOVE No. 2

Throughout the southern part of the Morris quadrangle one or more coal beds are found over No. 2 coal. The absence of such upper beds farther north is, of course, due to the absence of that part of the stratigraphic column. It is not clear whether this lack of the higher strata is because of non-deposition or because of erosion. The apparently lenticular form of the coal beds, however, leads to the inference that the northern limit of the depositional swamps was south of Coal City.

With the exception of one of these coal beds, it is impossible to make a satisfactory correlation of them even from well to well. The reported presence of a thin coal about 75 feet above No. 2 over the area between Waupecan Creek and Coal City leads to the inference that one of these beds may fairly be correlated, although absolute continuity is improbable. The one bed which appears to be persistent outcrops in section 20 of Wauponsee Township (T. 33 N., R. 7 E.) on Waupecan Creek. Here it was worked at an early date, as reported by Bradley,[34] who classed it as No. 4 coal. This bed shows a maximum development of 18 inches, but in most places pinches out to a mere streak in short distances. This same bed was worked on Mazon River in the vicinity of Sulphur Springs and in section 13 of Goose Lake Township (T. 33 N., R. 7 E).

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[33] Cady, G. H., Coal Resources of District I (Longwall): Ill. Coal Mining Investigations Bull. 10, p. 73, 1915.

COAL MINING

Early mining in this region was on a small scale. While some coal was taken from the outcropping beds in Goose Lake, Mazon River and Waupecan Creek, the amount was insignificant in comparison with that removed from No. 2 bed, the operations upon which will be noted in somewhat greater detail.

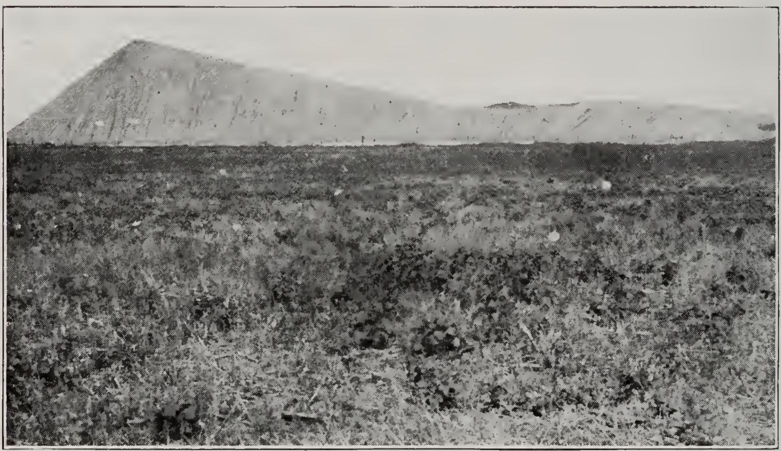

Fig. 41. Refuse dump 60 feet high, containing shale and impure coal from mine near Coal City

Strip mines were operated to a limited extent, but most of the coal cut was hoisted through shafts. The first of these were placed about a mile back of the outcrop of the coal beneath the drift. Extensive workings were not attempted, a new shaft being sunk as soon as the development from one bottom had proceeded a few hundred feet. This procedure was necessitated by the mining methods in use which met drainage, haulage and ventilation problems by withdrawing from the field of operations. When the most favorable sites for this type of mining had been found and utilized, openings were made to the northeast where roof conditions made operations uncertain and to the southwest where the greater depth to the coal increased operating expenses. But few shipping mines were attempted and the total production was not great from the early mining operations.

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[34] Bradley, Frank H., Geol. Survey of Ill. Vol. IV, p. 194, 1870.

With the discovery of thicker coal in the Braidwood district large shipping mines were started. These were profitable and the employment of the longwall system gave a high percentage of extraction. The huge dumps of shale and dirty coal which accumulated in these operations dominate the landscape in the vicinity of Coal City and indeed constitute the most prominent relief feature of the topography (fig. 41). Such dumps appear as far as 2 miles north of Coal City and may be seen south and east beyond the limit of the quadrangle. In 1920, but one shipping mine in the area was being worked. This was the No. 7 mine of the Chicago, Wilmington and Franklin Coal Company, and was located in section 5, 2 miles west of Coal City. No shaft has been sunk west of this point and because of the expense involved it is unlikely that the coal to the west will be worked in the near future. To supply part of the coal demand several wagon mines are operated intermittently. Three shaft mines known as the Mitchell, Heather, and Bell mines respectively are located north and west of the town of Morris. Figure 42 illustrates the surface equipment at the Mitchell shaft which is typical of these operations. Northeast of Morris two small strip mines have been opened. One, the Bell stripping, is in the SE. ¼ sec. 34, and the other, the Davidson stripping, is about one mile farther east. Figure 43 shows the thickness and character of the till overburden. The coal was partly under water when this place was visited.

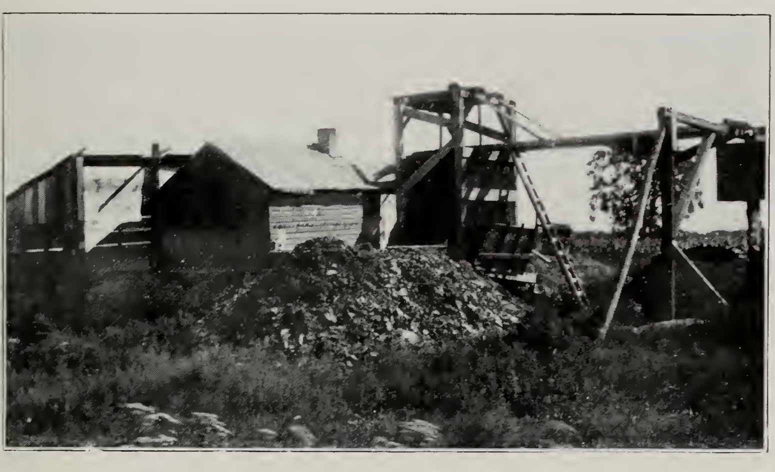

Fig. 42. Surface equipment for local mine. Mitchell shaft, Morris

Clay and Shale

As is usual in a coal mining region there are in the Morris area certain argillaceous deposits which are adapted to the manufacture of various clay products. The available material, however, is not restricted to the "Coal Measures" but is found in beds of earlier as well as later origin.

ORDOVICIAN SHALE

The Upper Ordovician section includes a shale member, the Maquoketa, which is quite uniformly about 60 feet thick and which outcrops beneath the drift in the belt mapped on Plate III. No surface exposures of this formation occur, however, and the drift and bed rock cover may be too thick for any but large scale operations. No tests have been made to ascertain the quality of this shale, which appears from drill cuttings to be free from grit or other impurities. Tests made on samples from the weathered portion of this formation in southwestern Wisconsin show it to be but slightly calcareous. It was there recommended for hollow ware and probably is suitable for paving brick though not in any sense a refractory material. It is likely that similar results would be obtained from tests of the Maquoketa of Grundy County.

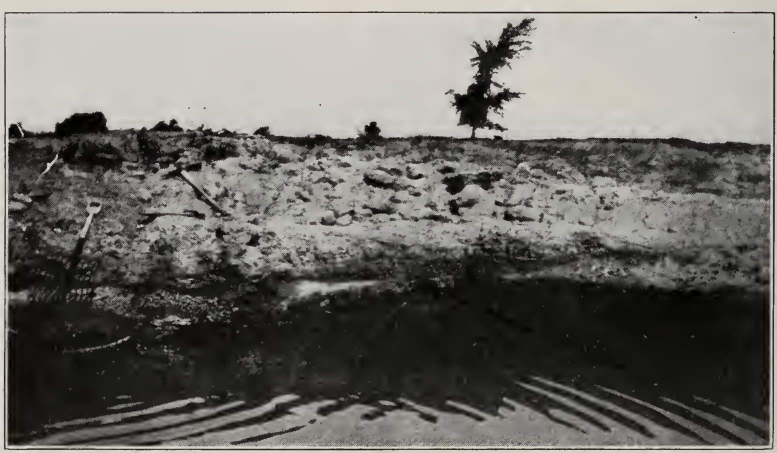

Fig. 43. View of small strip pit northeast of Morris. Note boulders in till of the overburden

PENNSYLVANIAN SHALE

From the Pottsville formation of the Pennsylvanian strata certain shales have been found adaptable to several uses. Such beds lie beneath the the Haeger Brick and Tile Company at the west end of Goose Lake. Stratigraphically these lie high in the Pottsville and perhaps are to be correlated with the clays mined at Rock Island, Colchester, and other places in the western part of the State. While the Jugtown clays are not known to be refractory, some of those of the Goose Lake depression are. In fact, tests made show that some of the shales compare very favorably with the best fire clays of the State. For that reason the Goose Lake clays are worthy of more than passing notice.

Even a cursory examination of this old lake basin shows that the stratigraphic relations are not simple. Three outstanding factors combine to produce the irregularities observed. There is first the basin's relief, which though low is still effective in producing an intricate areal pattern in the slightly dipping beds of the area. As a second factor there is the warping of the beds themselves which gives great variety to the general southward dip of the formation. Thus there are at the clay pit, at the west end of the former lake, beds dipping about 10 degrees south. Farther west these beds dip southeast about 1 degree and to the north they are dipping almost imperceptibly northward. In many parts of the basin the structure is not revealed by the outcrops and indeed the extent to which the recorded dip measures original inclination rather than warping is not known. The effect of the attitude of the beds, however, is to increase the complexity of their areal pattern. A third important factor is the lenticular character of the beds themselves. This is shown by the variation in the section from place to place as revealed by excavations and drilling.[35] Thus the sandstone encountered in the Haeger clay pit is distinctly lenticular. The coal, which is there about 60 inches thick, appears to be about 24 inches thick a few rods distant. Other stringers of coal from 1 inch to 6 inches thick can not be correlated from one test hole to another. In the same way the shales of the section appear to be lenticular. As yet sufficient work on either the extent of the shale beds or their refractory properties has not been done to delimit accurately the area underlain by fire clay. It is clear, however, that near the center of the lake basin some of the outcropping shales are distinctly refractory. One sample sent in to the Ceramics Department of the University of Illinois gave high tests,[36] fusing with cone 31 at a temperature of 1750°C. or 3182°F. This is a No. 1 fire clay and on the basis of its behavior when mixed with water would be classed as a semi-flint clay. As noted above, however, field data at hand do not make clear the extent of the area underlain by the more valuable deposits of refractory shale.

In the rocks stratigraphically over the Pottsville deposits just mentioned there occur similar shale and sandy shale beds which should be listed in a catalog of the clay and shale resources of the area.

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[35] The writer gratefully acknowledges his obligation to Mr. E. H. Van Schoick of Chicago Retort and Fire Brick Company, Ottawa, for data on the drilling tests made in the Goose Lake basin.

[36] Parmelee, C. W., Personal communication.

The "soapstone" roof of No. 2 coal is in most parts of the quadrangle a slightly gritty shale. In places it is very sandy but more frequently it is a clean shale. This is adapted to the manufacture of brick and drain tile although not mined with the coal for that purpose. A vast accumulation of this material, more or less mixed with coaly matter and pyrite, is found in the prominent mine dumps of the Coal City area. That this is available for the making of drain tile has been demonstrated by the commercial tests made by the Haeger Brick and Tile Company of Coal City.

It is not known exactly what deposits were used at Jugtown. Without doubt they belonged to the Pennsylvanian which comes practically to the surface in that vicinity. Whether the shales used were lying above or below the coal is not known but these may have been just below what is considered No. 2 coal. No tests on the refractory properties of this shale have been reported, hence it is not likely a high grade fire clay.

There are in the upper part of the Carbondale formation other shales which undoubtedly have properties rendering them suitable for brick and tile manufacture at least, but no attempt to test them out has been reported. Such beds are found below the Waupecan sandstone and farther down in the formation as exposed on Mazon River in the vicinity of Claypool Ditch.

PLEISTOCENE CLAY

Still younger in age and of different origin are the deposits referable to the Pleistocene or Glacial epoch. Two of these are being worked and the presence of other deposits of similar character is to be expected. The older of the two comprises the finely laminated lake clays on the East Fork of Nettle Creek in Morris and which are worked at the Morris Tile Factory. The deposit now worked is of rather limited areal extent, being restricted to an erosional depression in the surrounding Pennsylvanian sandstone. This deposit is a remnant of a rather extensive series of beds laid down in a glacial lake of pre-Marseilles age. Most of the original material has since then been removed by glacial and stream erosion. In protected places, however, remnants may be found.

These clays have long been used for brick and drain tile which, if properly made, appear to be entirely satisfactory. For further discussion of these beds the reader is referred to the chapter on Descriptive Geology (pp. 148-149).

The other Quaternary deposit is glacial clay, or till, a deposit made by the ice directly without the intervention of water to an appreciable extent. This material, while present over all of the quadrangle, is in most places so filled with cobbles and boulders as to be unavailable as clay. Locally it is essentially free from boulders and, as at Coal City, becomes a source of raw material for brick and tile. Much of the ground moraine area south of Illinois River above the 560-foot level may include workable beds similar to that at Coal City.

In early times brick and drain tile were made from all the types of deposits noted. In addition a rough type of pottery was manufactured at Jugtown from the Pennsylvanian shales. No other such operation has been reported from this area.

At present no pottery is being made and but two plants for brick and tile are in operation. The outlook for the future, however, includes the preparation of ground fire clay from the Goose Lake beds and operations looking to the establishment of this industry are already under way.

STONE

Both sandstone and limestone are available for structural work. The former has been used to only a very limited extent, and the latter very considerably.

The sandstone is of Pottsville age and that which was quarried outcrops just east of the Morris quadrangle between DesPlaines and Kankakee rivers. Ponds of regular shape mark the sites of the early excavations, and piles of dimension blocks reveal the character of the product, a soft stone of light color and of medium coarse grain. It was readily worked but probably the amount of water encountered was a serious obstacle to quarrying. No other sandstone quarry in the quadrangle is recorded.

The Galena dolomite of Middle Ordovician age was similarly used for construction at an early date. A few churches and schools in the region were built entirely of this stone and more commonly it served for barns and foundations. For such purposes the old Lisbon quarry, as well as one in section 34 of the same township and another in section 24 of Saratoga Township (T. 34 N., R. 7 E.) Grundy County, were originally opened.

While undoubtedly available for such use, the buff weathering of the stone renders it unattractive and there has been little reason for continuing the expensive operation of quarrying and cutting. As a result the quarrying now is carried on solely for the preparation of road material and an increasing mileage of crushed stone roads is being laid out. Lisbon Township owns the quarry site in section 21 and this is in operation from time to time as road material is needed.

The importations of crushed dolomite from the large quarries at Joliet have made impracticable the opening of other quarries in the quadrangle. The use of the Galena dolomite as a fertilizer to correct soil acidity has not been attempted. Laboratory tests [37] indicate a high neutralizing power for this rock and large scale experiments are suggested. Another limestone, the Maquoketa, which outcrops in the eastern part of the quadrangle is also of such purity as to be excellent for application to acid soils. Because of the interbedding of argillaceous strata with the limestone in Aux Sable Valley and the topographic position of the beds along the Illinois, large-scale operations are probably impracticable. As a local supply, however, such beds should be considered, since laboratory tests show this rock to have high neutralizing power.

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[37] Tests made by Mr. Victor E. Spencer of the Agronomy Department, University of Illinois, on samples of both Galena and Maquoketa limestones submitted by the writer.

A third source of fertilizer of this same type is found in the Quaternary deposits near Morris. In the overburden removed from the coal at Bell's stripping in the swamp area in section 34 of Saratoga Township (T. 34 N., R. 8 E.), there is a stratum of shell marl of such purity, thickness, and position as to be readily available for use as fertilizer. Its unconsolidated state renders it unnecessary to crush or otherwise prepare it for use, so that a limited supply is immediately available. The origin of this deposit leads to the inference that it is not widespread and since it has an average thickness of less than one foot it is believed that this will never be other than a supply to meet local needs.

Sand and Gravel

All deposits of these materials are of Pleistocene age. They comprise outwash deposits from the receding ice sheets and terrace deposits of fluvial origin. While restricted to certain belts, these deposits are sufficiently abundant to supply all the needs of the area for an indefinite period.

The main deposits lie within the old valley walls of the Illinois and are found up to an elevation of about 525 feet. Local gravel pits line the valley on both sides of the river and are found in some of the tributary depressions as well. The sites of many of these pits are shown on Plate II.

In composition the gravels are similar to those of the DesPlaines Valley, but are finer with a greater proportion of sand. Because of the proximity of the extensive DesPlaines gravels, the utilization of their downstream equivalents has been strictly local. They are available for both gravel and concrete road construction but because of the lenticular character of the deposits are expensive to work.

Aside from the beds within the main valley there are smaller related deposits along the major tributaries. Typical of these are the pits in sections 7 and 18 of Aux Sable Township (T. 34 N., R. 8 E.) along Walley Run and Aux Sable Creek.

Still another type is that found in the recessional moraines in the northwest part of the quadrangle. These comprise ill-assorted material including gravel, sand, and clay in varied proportions. The deposit opened in section 31 of Lisbon Township (T. 35 N. R. 7 E.) is one of this type. The material is available for road building but is not clean enough for other uses to which sand and gravel are commonly put.

WATER

The water resources of this area, while not in themselves of commercial importance are indirectly of the greatest importance in the industrial development of the region.

The Morris quadrangle, like the area surrounding it, is abundantly supplied with water. While in practically all cases it is "hard" water and in many it is a "sulphur" water as well, still the needs of the inhabitants are adequately supplied. In the vicinity of Sulphur Springs there are three wells from which a relatively "soft" water issues. The logs are not available and the horizon of the supply is not known. It is presumably some Pennsylvanian sandstone. Intermittent springs are common but are little used except for stock. Permanent springs, on the contrary, are not common. One of the largest in the vicinity lies a short distance west of the quadrangle in Nettle Creek Township. This is a remarkably cold water from which bubbles of marsh gas continually emerge.

Shallow wells, by which are meant those which do not penetrate the bed rock, are very common. In the valley of Illinois River below the 540-foot level such wells commonly reach an abundant supply at depths of less than 20 feet. Such a well is that in the northeast quarter of section 33 of Saratoga Township (T. 34 N., R. 7 E.) less than a mile north of Morris. One of the deeper surface wells is that recently drilled at the Stein School 1½ miles southeast of Morris where a good supply of water was found at 64 feet, probably but a few feet above the Pennsylvanian sandstone. Outside of the main valley the depth of the wells varies from place to place, the deepest surface wells being in the northeast part of the quadrangle where the drift is thick. Here reported depths of 100 feet are not rare.

While these wells in surficial material are found throughout the quadrangle, the search for water below the bed rock has been prosecuted systematically for two reasons. First, because it is believed that the chance of contamination is less, and second, because the deeper wells are usually artesian and the supply is more constant. While the artesian pressure is frequently not sufficient to produce a surface flow, or if produced at first not long maintained, the pumping required is much less than that for water from shallower wells. These deeper wells are drilled to depths which vary notably for several reasons.

Differences in topography make obvious differences in the depth at which water will be found. A second factor is the position within the quadrangle. Plate I shows clearly that a given water-bearing stratum, as the St. Peter sandstone, lies at greater depth toward the southeast part of the quadrangle. A third factor is the variation in the formations themselves. Thus a boring may meet a fair supply of water at 100 feet within the Galena formation while a well nearby may have to be sunk 200 feet in the same formation before finding any water. Similarly in the Pennsylvanian series a porous water yielding sand in one place may correspond stratigraphically to an impervious shale nearby.

As a rule the water from the deep wells is hard and those penetrating the "Coal Measures" are more or less sulphurous. They are in most cases very regular in supply although over a long period of years the gradual lessening in the flow is perceptible. In some cases this is due to the failure of the supply, in others to the slow clogging of pipes with iron rust, clay, etc. Some wells have ceased abruptly and disturbance by blasting or earthquake has been assigned as a cause. The permanence of the flow and the height of the water column, as well as the character of the water, are closely related to the source of supply.

Drilled wells draw water from several formations. In the southern half of the quadrangle many wells are bottomed in the Pennsylvanian beds. Because of the proximity of the outcrop and the consequently restricted area of intake, this source of supply is less reliable than that next below. The common practice is to drill for water in the upper beds and if it is not found there, to continue to the beds below. In places the water of the "Coal Measures" is too sulphurous and in these cases drilling is usually continued, the upper waters being cased off to prevent their joining the purer water encountered below.

The next water-bearing stratum below the Pennsylvanian rocks is the Galena dolomite. This has no definite water horizon but is rarely completely penetrated without finding a good water supply. While uniformly "hard" this is an excellent source for water. More wells obtain water from this stratum than from any other in this area.

Below lies the St. Peter sandstone, a noted aquifer and one that is frequently reached in the northwestern part of the quadrangle but rarely elsewhere.

The next water-bearing stratum is in the Lower Ordovician beds where the sandstones and limestones of the Prairie du Chien formation supply water that in most cases is abundant but rather highly mineralized. These beds have been tapped but no well is known to give water from these beds at present. One well in section 10 of Saratoga Township (T. 34 N., R. 7 E.) which is reported as 1,200 feet deep presumably is supplied from this source but the lack of an accurate log renders this uncertain. In this case the water is too highly mineralized for domestic uses and a second well stopped in the Galena dolomite furnishes the supply.

A still deeper supply is that in the "Potsdam" beds of Cambrian age. This has been reached in two wells, that at Minooka, 2,100 feet deep, and that on the farm of Abe Hoge in section 25 of Nettle Creek Township (T. 34 N., R. 6 E.). This water was in both cases found to be under considerable pressure but was so highly mineralized as to be suitable for stock only.

The conditions requisite for artesian pressure obtain in all parts of the quadrangle and with few exceptions the water in drilled wells rises many feet above the source stratum. As noted earlier, the flowing wells are not rare although pumping is frequently resorted to as a means of furnishing an adequate supply. Particularly is this true in the case of old wells.

Adequate data are not available to show the relative pressures obtained, but the water from the Cambrian beds is under the greatest head and the shallower wells show a lower pressure which roughly corresponds to the depth of the source. At least one flowing well has been reported from the drift. This was drilled in the valley fill of the Illinois to a depth of 53 feet and a flow of 20 gallons per minute obtained. The Galena was just penetrated, however, and although the supply was reported to come from the surface material the assertion cannot be proved. On Plate II no attempt has been made to distinguish between wells having artesian pressure and those which actually flow, since such distinction would necessitate annual revision. All surface wells may therefore be considered as non-artesian and all deep, or bed rock, wells as artesian.

Some data as to the height of the water level in these wells have been obtained, but this, too, is variable. In general the water level is higher at the northwest and lowest along the Illinois valley, ranging from about 600 feet above sea level in the former area to less than 500 feet in the latter. South of the river the level attained is about 550 feet; but the data here are few, most of the wells not penetrating bed rock. For details as to the supply and character of waters in this area the reader is referred to a recent report by the Survey.[38]

SOILS

While the minute differentiation of soils lies outside the province of the geologist the close relation between the geologic events of a region and the formation of its soils makes a review of the soil determination of interest. On that portion of the Morris quadrangle lying within Grundy County many soil types have been mapped as a result of a survey made by the Illinois Agricultural Experiment Station.[39] The Kendall County portion has not yet been mapped.

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[38] Anderson, C. B., Artesian waters of northeastern Illinois: Ill. State Geol. Survey Bull. 34, 1919.

[39] Hopkins, Cyril G., et al., Soil Survey map of Grundy County.

The soils reported are listed below:

1. Deep brown silt loam
2. Brown silt loam
3. Brown silt loam on rock
4. Brown sandy loam
5. Brown sandy loam on rock
6. Brown sandy loam on gravel
7. Brown-gray silt loam on light clay
8. Brown-gray sandy loam on light clay
9. Yellow silt loam
10. Yellow-gray silt loam
11. Yellow-gray sandy loam
12. Yellow-gray sandy loam on gravel
13. Mixed loam
14. Black sandy loam
15. Black clay loam
16. Peaty loam on clay
17. Deep peat
18. Muck
19. Dune sand

Areally the brown silt loam is the most important. This, with the associated black clay loam, covers a large part of the quadrangle. A large part of the remaining area is covered by the brown sandy loam which has developed from the original till surface through weathering and the introduction of stream and wind-borne sand. The prominent area of this type of soil is in the Coal City region.

Most of the other types of soil are restricted to the Illinois Valley where, as noted in the earlier chapters, the geologic events recorded have produced areas of deep sand and gravel, of bed rock, of silts, and of swamp deposits. These beds give rise to some of the reported soil distinctions, since not only the surficial character but the sub-soil conditions are considered. Along the stream courses are found the upland timber soils, including yellow-gray loams either silty or sandy. Where slope wash is more prominent yellow silt loam is found, the accumulation of black soils being prevented by the constant removal of the finer material. The soil of the alluvial flats of the Illinois is classed as a deep brown silt loam, and is of such thickness that the character of the sub-soil is unimportant. The flood plains of the smaller streams are so continually being added to from various sources that their soil covering is well classed as mixed loam.

The undrained areas of the Cryder Lake basin as well as of the later drainage courses provide conditions for the development of the peaty or muck soils there found. The dune sand is of limited extent and restricted to the southeastern part of the quadrangle.

It should be noted that the soil distinctions, while clear, are to a certain extent arbitrary and that in any classification the pure types have undue prominence while the more common gradational types are relatively inconspicuous.

In general, the soils of the quadrangle are transported and have resulted from the weathering of a variety of materials. They are very fertile on the whole, the poorest lands being in the area where bed rock lies near the surface.

OIL

In an examination of the area for determination of the possibilities of the presence of oil, there are three major factors to be kept in mind: (1) the presence of any oil in the region in either large or small amount, (2) the presence of beds which are known to contain oil in other localities, and (3) the presence of such structures as favor the accumulation of oil.

Very few, if any, tests for oil have been made within the limits of the quadrangle, the nearest which has been reported being a few miles east of Minooka on the north bank of DuPage River. The only discovery of oil of even small amount was within the No. 7 mine of the Wilmington Star Mining Company, where a small seepage was found several years ago.

Within the Morris quadrangle there are two formations at least which are known elsewhere to furnish oil in commercial quantity. These are the Pennsylvanian beds, which outcrop at the surface and dip to the southwest beneath a fairly heavy cover of glacial drift, and the Galena dolomite, which outcrops in the northwest portion of the quadrangle, and which is probably to be correlated with the so-called "Trenton."

As was noted in the chapter on the structural geology of the area, the Ordovician formations may lie in a southeastward pitching fold whose axis runs through Coal City. As was pointed out, however, because of the paucity of data this structure cannot be considered as determined. If it exists the broad belt there outlined would be the most favorable locus for drilling.

The contours on the surface of St. Peter sandstone, as represented on Plate III, show an irregularity in the southwest part of Saratoga Township. Two interpretations of the data were presented on p. 30. On the assumption that this irregularity results from the upwarping of the Ordovician beds, this area would be the logical place for testing with the drill.

With regard to the Pennsylvanian beds, it is evident that the accumulation of oil in commercial quantity is not likely to have occurred in that portion lying within several miles of the line of outcrop since here the beds appear to have a fairly uniform southwestward inclination. Between the apparent trough, southwest of Coal City, and a similar but less marked downward fold just west of the quadrangle lies an area where the beds appear nearly flat, If any of the sandstones here contained oil, as has not been demonstrated, this would be an area in which an accumulation might be expected.

In the absence of any thorough drilling for this region, it should not be assumed that there is no possibility of oil production, although as indicated in the above statements, there is little to indicate the possibility of finding oil in commercial quantity.

GEOLOGY AND MINERAL RESOURCES OF THE KINGS QUADRANGLE

By J HARLEN BRETZ

OUTLINE

PAGE

Chapter I.—Introduction 209

Chapter II.—Interpretation of the geologic record........ 211

  Introduction 211

  Processes and agencies........ 211

    Running water 211

    Ground water........ 212

    Marine sedimentation........ 213

    Glaciation 214

    Diastrophism 215

    Wind 217

    Weathering 217

Chapter III.—Stratigraphy of Kings quadrangle........ 219

  Indurated formations........ 221

    Potsdam sandstone........ 221

    Prairie du Chien ("Lower Magnesian") limestone........ 222

    St. Peter sandstone........ 223

    Platteville (Trenton) and Galena limestones........ 226

  Unindurated formations........ 232

    Pre-Illinoian gravel 232

      Other pre-Illinoian deposits........ 234

    Illinoian drift........ 235

      Illinoian till sheet........ 235

      A gravel deposit showing deformed stratification........ 237

      Loess and loess-like loam........ 238

    Wisconsin drift........ 239

      Deposits within the quadrangle........ 239

      Early Wisconsin drift........ 239

        Differences between the early Wisconsin and the Illinoian........ 241

        Composition of the drift........ 244

        Early Wisconsin gravel deposits........ 246

          Stillman Valley eskerine tract........ 246

PAGE
Big Mound kame.. 251
Killbuck kame tracts.................................. 252
Holcomb kame tract.................................... 254
Kings kame tract...................................... 254
Other kame tracts..................................... 255

The Killbuck Valley train............................. 255

Late Wisconsin drift.................................. 255
Valley trains... 255

Recent deposits....................................... 258
Loess-like loam....................................... 258
Dunes 259
Alluvium 259

Chapter IV.—Geological history of the region.......... 261
Cambrian history...................................... 261
Ordovician history.................................... 263
Post-Ordovician pre-Pleistocene history............... 266

Cementation and consolidation of the sediments........ 267

Compression 267
Cementation 267

Development of chert concretions...................... 268
Dolomitization 268
Jointing 268
Warping 268
Sedimentation and erosion............................. 270

The cycle of erosion.................................. 271
Pre-Illinoian topography 273

Pleistocene history 277

Pre-Illinoian glacial epoch........................... 277
Pre-Illinoian interglacial epoch...................... 277
Illinoian glacial epoch............................... 278
Post-Illinoian pre-Wisconsin history.................. 283

Events in Kings quadrangle............................ 283
Events elsewhere in the upper Mississippi Valley...... 288

Wisconsin glacial epoch............................... 288

Early Wisconsin glacial epoch......................... 290
Interval between the Early and Late Wisconsin epochs.. 292
Late Wisconsin glacial epoch.......................... 292

Post glacial history.................................. 293

Chapter V.—Economic geology 297
Building stone 297
Crushed rock 297
Gravel 297
Ground water 298
Soils 302

ILLUSTRATIONS

PLATE

IV. Geology of the Kings quadrangle .... Pocket
V. Outline map of Illinois, showing the location of Kings quadrangle and the principal meridians and base lines 208
VI. Kings quadrangle and vicinity while the Early Wisconsin ice was building the Bloomington moraine and Marengo Ridge after its recession from the Belvidere area 238

FIGURE

44. Nugget of native copper, found in Kings quadrangle 214
45. Views illustrating the characteristics of glaciated pebbles and rock surfaces 216
46. Diagram showing an unconformity in a series of horizontal formations 217
47. Columnar section of the formations of Kings quadrangle 220
48. Galena limestone in Carrico quarry, Rockford 227
49. Platteville limestone in quarry 1½ miles west of Stillman Valley 227
50. Sectional and surface views of Receptaculites, "sunflower coral" or "lead sponge" 228
51. Inclined stratification in kame gravel, Winnebago County 237
52. Tilted ledges of Galena dolomite thrust upon fossiliferous loess in quarry, sec. 20, T. 43 N., R. 1 E. 240
53. Diagram showing graphically the number of borings in the Belvidere Lobe and the Illinoian areas which revealed a given depth of leaching 242
54. Views of the central ridge of the Stillman Valley eskerine tract 244
55. Diagrammatic longitudinal section of the central ridge in Stillman Valley eskerine tract 245
56. Diagrammatic cross section of the central ridge in Stillman Valley eskerine tract 246
57. Block diagram to show the phenomena at the margin of a retreating glacier 247
58. Map of Stillman Valley eskerine tract 248
59. Crest lines of gravelly ridges in the Stillman Valley eskerine tract 249
60. Big Mound from the southwest 251
61. Diagrammatic section of Big Mound 253
62. Terrace in Pleistocene lake bed at Stillman Valley 258
63. Loess-like deposit in southern part of Rockford 258
64. Ripple marks in Galena limestone 266
65. Cross sections of valleys in different stages of the cycle of erosion 272
66. Diagrammatic section on Dixon, Kings, and Rockford quadrangles showing divergence between summit levels and structure 274
67. Map of North America showing the area covered by the Pleistocene ice sheets at their maximum extension, and the main centers of accumulation. 278
68. Map showing glaciated area of Illinois 280
69. Pre-Illinoian drainage pattern superposed upon the present drainage lines 282
70. Location and direction of flow of the drainage during the interval between the Illinoian and Early Wisconsin epochs of glaciation 282
71. Ledges of Galena limestone exposed in the post-Illinoian valley of Hall Creek 284
72. Illinoian drift exposed in Chicago, Milwaukee, and St. Paul Railway cut, seven miles south of Rockford 286

73. Diagrammatic section between Rockford and Byron along Rock River valley, showing relations of the present valley of Rock River to the preglacial topography, and the valley fillings of glacial drift 289
74. Narrow valley of Kishwaukee River at the rifle range east of New Milford .. 291
75. Cross sections showing relations of the present channel of Rock River to the preglacial valley, the glacial drift, and the underlying rocks 293
76. Map showing outcrop of Potsdam and St. Peter formations in Wisconsin and Illinois 299
77. Diagram to explain artesian conditions in the Potsdam and St. Peter formations beneath Kings quadrangle 300

TABLE

7. Geologic time divisions showing periods for all geologic time, and epochs for those periods recorded in north central Illinois 262

73.

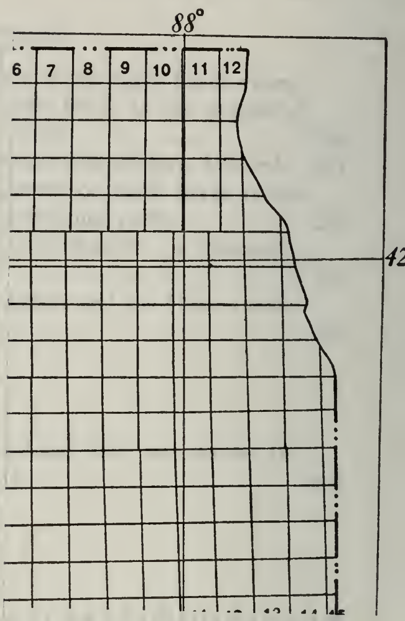
74

75.

76.

77.

7



CHAPTER I—INTRODUCTION

Kings quadrangle which lies in northern Illinois, about 80 miles northwest of Chicago, extends from Rockford on the north to King station on the south and from Monroe Center on the east to Byron on the west. It includes the southern part of the city of Rockford and all of the Camp Grant reservation, and comprises portions of four townships of Winnebago County and all or part of seven townships of Ogle County (Pl. IV). In conformity with the practice of the United States Geological Survey in delimiting "quadrangles," it is bounded by latitude and longitude lines rather than by political boundaries. The quadrangle lies between the meridians of 89° and 89° 15′, and between the parallels of 42° and 42° 15′,[1] a total area of about 240 square miles, or one-sixteenth of a square degree. From its dimensions of 15′ of latitude and longitude, it is known as a "fifteen minute" quadrangle.

The land survey of the United States Government selects a precisely located point and draws through it an east-west line known as a base line, and a north-south line known as a principal meridian. East-west rows of townships are known as tiers, and are designated as T.(ownship tier) 1 N.(orth), T. 2 N., T. 3 N., etc., or T. 1 S.(outh), T. 2 S., T. 3 S., etc. Rows extending north-south are known as ranges and are enumerated as R.(ange) 1 E.(ast), R. 2 E., R. 3 E., etc., or R. 1 W.(est), R. 2 W., etc.

In practice there is considerable divergence from this simple scheme, and Kings quadrangle shows it strikingly. The designation of townships in Illinois is based on two principal meridians and two base lines as shown in Plate V.[2] Illinois River represents the western limit of the territory controlled by the Third Principal Meridian and its base line. Since it joins this meridian in the north-central portion of the State, the area controlled by the fourth principal meridian is correspondingly increased until in the four rows of northern counties, the Third Principal Meridian controls only the country east of itself. Thus in Kings quadrangle, which is crossed by the Third Principal Meridian, the townships west of this meridian are numbered eastward from the Fourth Principal Meridian and northward from its base line, while on the east of this line, townships are enumerated from it and from its own base line, nearly twice as far distant as the base line controlling the west side.

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[1] The parallel of 42° 30′ is the northern boundary of the state of Illinois.

[2] Except for a narrow strip along the eastern margin of the State, where an Indian meridian and base line control the scheme.

The Third Principal Meridian passes through the extreme eastern portion of the village of Stillman Valley. Except for about four miles, it is followed across the quadrangle by the Third Meridian Road. This is not to be confused with the "Meridian Highway" which runs south out of Rockford across the quadrangle.

The main drainage line of Kings quadrangle is Rock River, which enters in the middle of the north side at Rockford and leaves in the middle of the west side at Byron. Its meandered length on the quadrangle is fifteen and one fourth miles. Rock River and the Kishwaukee which joins the Rock from the east five miles below Rockford, lie in the northern half of the quadrangle. Except for the extreme southern part of the area, nearly all surface drainage finds its way within the limits of the quadrangle to one of these streams. Stillman and Killbuck creeks, both northward-flowing streams, are the largest streams whose drainage areas lie largely within the limits of the quadrangle.

The highest altitudes in the region do not much exceed 920 feet above sea level. The lowest altitude is the bottom of the Rock River valley at Byron, where the elevation is less than 680 feet. The maximum relief, therefore, is at least 240 feet. The highest areas of the quadrangle are marginal, and are separated by low gaps, one on the north where Rock River enters, one on the east where Kishwaukee River enters, one on the southeast where Killbuck Creek enters, and the lowest of all on the west where Rock River, with all tributary drainage, leaves the region. The largest lowland tract extends from Rockford on the northern margin south to the center of the quadrangle where Kishwaukee River and Killbuck Creek join Rock River. Thus most drainage lines of the quadrangle converge toward the middle of the western margin.

A large part of Kings quadrangle is in slopes, most of which are gentle, however. The only flats are in the valley bottoms, aggregating not more than 30 square miles. Steep slopes are restricted to the narrow portions of the stream valleys, notably those of Kishwaukee River east of New Milford, and of Rock River between Camp Grant and Byron. Here are numerous vertical and even overhanging cliffs, in striking contrast to the broad rolling surfaces which cover more than five-sixths of the quadrangle.

The area is covered almost wholly with soil and unconsolidated deposits. There are not more than three square miles in the entire quadrangle where the solid rock outcrops or bears a soil too thin for tillage. The unconsolidated materials are largely glacial deposits, covered with the products of stream deposition in the lowland flats on the slopes, while doubtless some of the finer loam has been deposited by the wind. Almost none of the soil of the region has been formed by decay of the underlying bedrock, though this is the most common method by which soils are formed.

CHAPTER II—INTERPRETATION OF THE GEOLOGIC RECORD

Introduction

A mere description of the rocks of a region and of their economic uses does not constitute a geological report. Geology, in a broad sense, is the history of the earth, the record and the interpretation of *change*. The earth is not a finished product; agencies under our observation are everywhere changing its surface at the present time, though the rate of change is very slow compared with the rate of progress of human events. These agencies have been operative throughout the recorded past, and some of their results have been nothing short of revolutionary. Areas now land have been for long ages below the sea; regions of gentle relief have been the site of lofty mountains; districts of fertile farming land have been the scene of volcanic eruptions or have been buried beneath thousands of feet of glacial ice; areas now frigid formerly have supported palms, fig trees, magnolias and other subtropical plants. Some but not all of these great changes are recorded within the area of Kings quadrangle.

Past conditions and events of earth history are recorded largely in the rocks of a region, i. e., the rocks are the product of past conditions. The present represents the cumulative result of the past. Thus a comprehension of the geology of a region as it is today involves an understanding of the geological *history* of that region.

Processes and Agencies

The geological changes now going on in Kings quadrangle are *gradational. Degradation,* or wearing away, is everywhere occurring on the slopes and highlands, and *aggradation,* or building up, is in progress to some extent on the lower tracts. The agencies responsible for the gradational changes are running water, ground water and wind.

RUNNING WATER

The average annual rainfall in this region is 35 inches of which more than a third, perhaps a half, flows off the fields and down the slopes in rivulets and streamlets converging in the definite water courses. Most of the streams exist only during and immediately after rains and the melting of snow. Others flow throughout the year. But whether intermittent or permanent, these streams are muddy, and in flood time carry sand in suspension and roll pebbles along their bottoms. The inevitable result of such action, continued through the centuries, is to lower the region by the removal of the loose material commonly called soil and subsoil.

Measurements of Rock River at Rockton, 14 miles north of the limits of Kings quadrangle, have shown a flow of .773 second-feet[1] per square mile for the Wisconsin drainage area of this stream, amounting to nearly 700,000 tons of water per square mile per year. If this run-off descended an average slope of 50 feet to the mile in its flow to the permanent streams, it would produce nearly four and one-half horse power constantly operating on every square mile of surface before the water became concentrated into streams, where its work is more pronounced and conspicuous. The adequacy of running water to wear down the land through long intervals of time is thus apparent.

GROUND WATER

That part of the precipitation which sinks into the ground moves downward so slowly that all porous rocks a few feet or a few tens of feet below the surface are kept continually saturated. The upper limit of this saturated rock or soil is the ground water surface, or *water-table.* In general it is nearer the surface in valleys than on hills and in many cases the valley bottom is below the level of the water table. This condition results in springs and seepages along the lower parts of the valley slopes, and a permanent stream in the valley, or, if the depression is a basin, the result is standing water, as in a lake or a swamp. Wells must be dug or drilled below the water-table. Quarries, mines, etc., excavated below this level must be pumped constantly, or they will fill with water.

The velocity of ground water through the pores and cracks is too slow to produce the mechanical changes which result from the work of water running off over the surface, but it produces changes of other sorts, chief among which is *solution.* The ground water which issues in springs or other seepage carries great quantities of mineral matter in solution. It is this dissolved material which forms the scale in tea kettles and steam boilers, and which makes water "hard". The chief substance thus removed from the ground is calcium carbonate, the dominant constituent of limestone.

Besides its solvent action, ground water combines chemically with some minerals or with their elements resulting in a change known as *hydration,* one of the causes for the crumbling of solid rock into soil. Rain water is thoroughly aerated by the time it enters the ground, and two of the absorbed atmospheric gases, oxygen and carbon dioxide, produce chemical changes in the rocks. *Oxidation* is best shown by the rusting of iron-bearing minerals, and their final transformation from constituents of solid rock, to the material of reddish-stained soils. *Carbonation,* the combination of carbon dioxide with elements in the indurated rocks, results largely in the production of calcium carbonate, which is dissolved by the ground water. This also causes the disintegration of originally solid rock, and helps to produce soil.

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[1] A second-foot is the flow of a cubic foot of water in a second of time.

The geological changes above outlined are known to have occurred in this region in the past as well as in the present, but not continuously. Other gradational changes not now taking place in the region have alternated with them, two of which will be outlined in the following paragraphs.

MARINE SEDIMENTATION

The indurated rock, or bed rock, of the region is stratified, consisting of alternating sandstones and limestones, known from drilling to a depth of more than 2,000 feet. Originally these formations were unconsolidated sands and calcareous muds deposited in layers or strata at the bottom of shallow seas, in more or less open connection with the oceans which, then as now, surrounded the continent of North America. When the sands were deposited, the shores of the ancient seas were not far from this region, and the currents caused by waves and tides were strong enough to carry the sand grains along the bottom for some distance from the land which yielded the material. When the calcareous muds were deposited, the shores were perhaps farther from this region, the water was probably a little deeper, and surely much clearer and less disturbed by waves and currents. The debris accumulated under these latter conditions was derived largely from the shells and other hard parts of marine animals living in those seas. Only fine mud, which could be carried in suspension far from the land, was mingled with this organic sediment.

Subsequent to the deposition of these marine sediments, the originally incoherent materials have become indurated, partially by compression, but largely by cementation. Ground water has been the means of introducing mineral matter in solution, which by its precipitation between the grains, has produced a consolidated rock from material originally unconsolidated.

The consolidated formations in their present condition commonly are not traceable continuously between two places where they may be exposed. Identification in such case must be based on some features in the formation which do not occur in the overlying or underlying rock, and yet which occur widely distributed in that particular formation. If there were no such features, outcropping formations could not be correlated across wide areas with no exposures, and the science of geology would be very limited.

The one reliable criterion for this purpose of correlation is *fossils,* the impressions or petrifactions of plant or animal organisms which lived in the region while the sediments were being deposited. The existence of fossils has been known for many centuries, but the fact that each of the different formations in one region contain different assemblages of such forms was first recognized in England about 125 years ago. It now is one of the most important of geological principles. After careful study of the embedded fossil forms, sedimentary formations may be correlated across great gaps, perhaps some hundreds of miles wide, in which no outcrops of those formations occur.

GLACIATION

The non-indurated rock of the region, commonly called the subsoil, is largely unstratified stony clay. It is not the product of weathering of the underlying sandstones and limestones, but contains boulders and pebbles utterly unlike the subjacent bedrock. Granites and fine-grained lavas which have solidified from a former molten state; gneisses whose twisted and gnarled structures tell of tremendous pressures and movements in the throes of mountain-making; and a great variety of other allied types of rock are represented in the stone piles of almost every farm, and in the gravel pits of the whole region. One of the most striking kinds of foreign boulders in Kings quadrangle is an igneous rock with crystals of glassy quartz and pink-to-red feldspar, set in a red ground-mass which, to the naked eye, does not appear crystalline. It has been termed *red quartz porphyry* and is widely distributed in southeastern Wisconsin though its parent ledges are probably north of Lake Superior or Lake Huron.

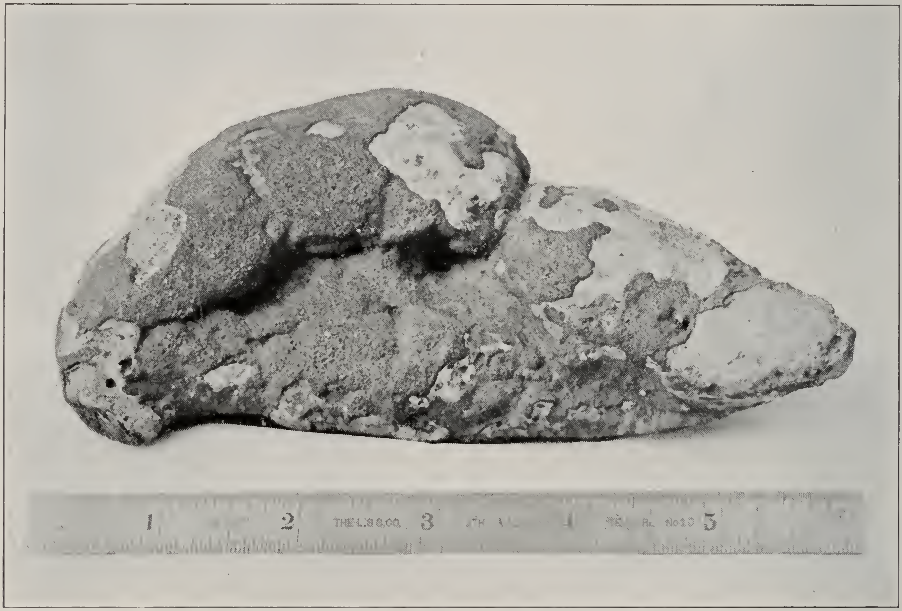

Fig. 44. Nugget of native copper, found in Kings quadrangle.

Another striking kind of foreign material in the subsoil is native copper (fig. 44) in scattered pebbles and small boulders. The copper has doubtless been brought from the south shore of Lake Superior and the igneous rocks, in large part, have come from Canadian territory still farther distant.

Associated with these less abundant materials is an immense amount of limestone gravel from a formation much younger than any underlying the quadrangle. All of the parent formations, from which these fragments have come, lie to the north and east. They have been brought by an agency which carried and deposited particles of all sizes, from huge boulders to the finest clay, in intimate association. Neither wind nor water does this. Further, they have been brought by an agency which drags them under great pressure, planing, beveling, and scratching them, and at the same time smoothing and fluting the surface of the bed rock, leaving long, parallel scratches in the direction in which the debris was moved. (See fig. 45.) There is but one gradational agent which does these things, and that is glacial ice. The stony clay which it deposits is known as *till,* or sometimes as *drift.*

DIASTROPHISM

The stratified bed rock of the Kings quadrangle, with its entombed marine fossils, is undisputable evidence that the region was at some time in the past beneath the water of the ocean, or rather beneath seas which were embayments of the oceans. The region now stands several hundred feet above the sea level. These two facts indicate either that the region has been raised many hundred feet since the strata were deposited, or that the sea level has been lowered that amount, or that both movements have taken place, the sum of the two approaching, if not reaching, a thousand feet. Movements in the body of the earth, manifest in warpings of the exterior explain such changes in altitude. Downwarp of the ocean basins would draw off the waters; upwarp of the continent, or a part of it, would convert areas covered by shallow water into land. Such movements in the earth's body are manifestations of the process called *diastrophism.*

Should the region as it now exists be submerged beneath the sea another time, mud, sand, or calcareous materials would again be deposited, and these would rest on the present irregular surface. More than 2,000 feet of sediment is known to lie below the surface; how much more is not known. If the present surface were buried beneath new marine sediments, the surface of contact between the latter deposit and that already deposited would be about as irregular as the present topography. In section, it would resemble the relationships shown in figure 46. Such contacts are termed *unconformities.* If the strata involved are marine they record the presence of the sea over the region, the withdrawal of the sea and the action of degradational agents, and the return of the sea and the renewal of marine deposition.

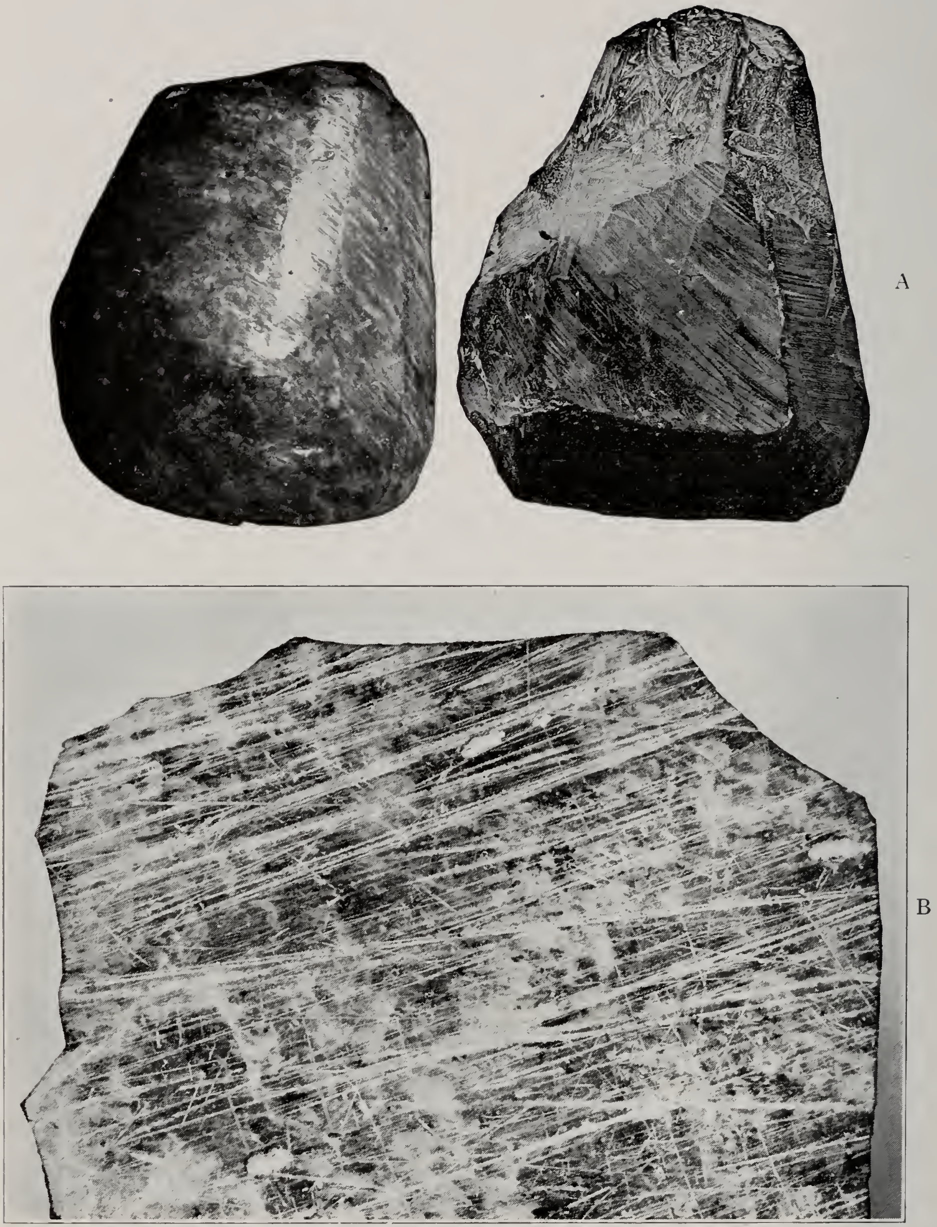

Fig. 45. Views illustrating the characteristics of glaciated boulders and rock surfaces.
A. Beveled and striated pebbles from glacial deposits. (Henry Holt and Company).
B. Planed and striated rock surface produced by glacial erosion.

WIND

Air in motion produces only mechanical changes, and these largely only when it is supplied with loose material, thus wearing away exposed surfaces of indurated rock in a manner similar to the action of a sand blast. More commonly the results of wind action are the removal of fine, loose material from one place (erosion or degradation) and its accumulation in another (deposition or aggradation). Material so moved must of necessity be composed of small particles. Soil may be blown away from places devoid of sufficient moisture or vegetation to hold it. Sand grains will accumulate in the lee of obstacles which check the wind, eventually forming *sand dunes*. The finer constituents may be carried in suspension as dust for miles and be deposited finally as a widespread mantle, which, in sufficient thickness, constitutes a formation known as *loess*.

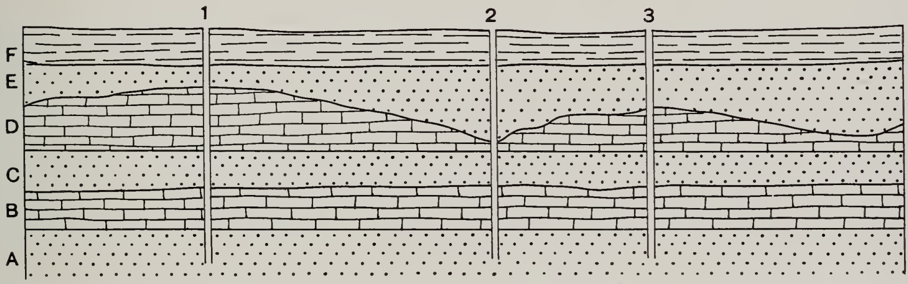

Fig. 46. Diagram showing an unconformity in a series of horizontal formations. This relationship is detected by a comparison of the records of the wells 1, 2 and 3, even when the contact is not seen.

WEATHERING

The sum total of all unobtrusive processes by which solid rock is reduced to an unconsolidated condition is known as weathering. In addition to the processes and agencies already mentioned, the following are worthy of note in this elementary review: (1) differential expansion and contraction of solid rock from daily changes in temperature; (2) expansional force of the freezing of water in pores and crevices; (3) that due to the wedge work of plant roots growing in cracks in the rock; and (4) the burrowing of animals. It is obvious that any rock, however firmly indurated, must slowly disintegrate during the passage of years from the attack of these varied agents. The result is a tendency to form a mantle of unconsolidated material on the surface of all outcrops of indurated rock, save those too steep to retain it—a mantle of material physically and chemically unlike the underlying parent rock. This loose cover above solid rock is best termed *mantle rock*. Its upper portion with which is mingled the carbonaceous matter of decayed plant tissues is generally called soil.

CHAPTER III—STRATIGRAPHY OF KINGS QUADRANGLE

The rocks in Kings quadrangle may be subdivided into two groups for convenience in describing the strata—the indurated bed rock below, and the non-indurated mantle rock above. The indurated rock, or bed rock, of the region is stratified. Its total measured thickness down to the bottoms of the deepest wells, exceeds two thousand feet. Five formations, as commonly recognized by geologists, are known, the lowest two of which do not appear at the surface within the limits of the quadrangle (fig. 47). These formations, in the order of their superposition, are:

5. Galena limestone.
4. Platteville or Trenton limestone
3. St. Peter sandstone.
2. Prairie du Chien or "Lower Magnesian" limestone.
1. Potsdam or Croixan sandstone.

The non-indurated rock of the region, commonly called the subsoil but better termed the mantle rock, is largely till, consisting of unstratified stony clay. It extends over almost all the region, lying on the bed rock. Above the till and interbedded with it is stratified sand and gravel, indurated little or not at all. The distribution of the gravel is patchy, none of the patches, however, covering more than a few square miles. The unstratified and stratified non-indurated rock constitute the drift. The till is the direct deposit of glacial ice, but the stratified sand and gravel are the products of water which came from the melting of that ice.

Glacial drift of four different ages exists within the quadrangle. The lowest of these drifts is gravel whose outcrops are limited to a small area southeast of Rockford. The next younger drift lies at the surface in the northern, western, and southwestern parts of the quadrangle, and passes beneath a younger drift in the eastern part. The youngest drift is a gravel deposit limited to the Rock, Kishwaukee, and Killbuck valleys. Named in order of superposition, the drift deposits are:

9. Late Wisconsin valley trains of Rock and Kishwaukee rivers.
8. Early Wisconsin till and gravel.
7. Illinoian till and gravel.
6. Pre-Illinoian gravel.

Stratigraphically above the two youngest drifts is post-glacial material, largely wind and stream deposits. The wind deposits are on the whole thicker on the older drift.

It is evident that the order of superposition of these formations gives the relative ages; the oldest or first deposited being at the bottom and the youngest or last deposited at the top. The numbering of the formations listed above has reference to relative ages.

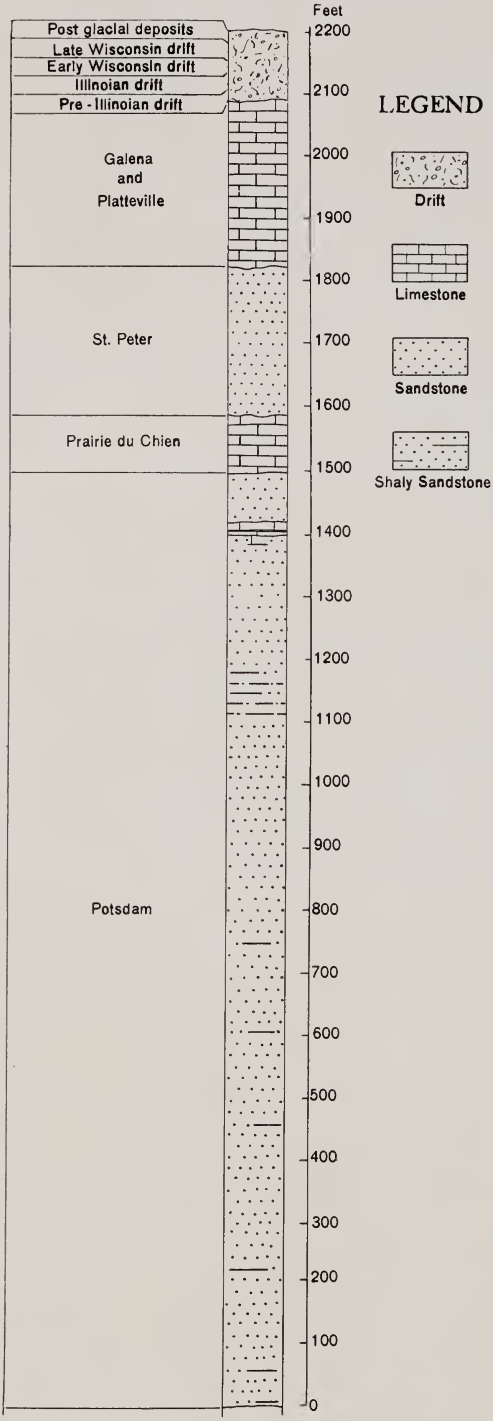

Fig. 47. Columnar section of the formations of Kings quadrangle. The thickness of each formation shown is the maximum reported for this area.

The character of the material in the different formations records the conditions under which each was deposited. The limestones are clearly marine deposits and record the presence of clear sea water over the area where they occur. Sandstones are not so clearly a record of submergence below sea level, though they record widespread deposition of sand while the region lay at a low altitude. The unconsolidated till or stony clay is identical in kind with the material being deposited to-day by glacial ice, and the associated gravel has its homologue in the deposits of streams formed by the melting of glacial ice. Both the till and the gravel contain pebbles and boulders derived from the highlands of Lake Superior and Canadian territory north of the Great Lakes.

Indurated Formations

POTSDAM OR CROIXAN SANDSTONE

Potsdam sandstone is reached by the city well at Byron and by a number of wells at Rockford. It was encountered at about 500 feet below the valley floor at Rockford, and has been penetrated to a maximum of 1515 feet at this city. The Potsdam formation does not outcrop in Illinois, nor has its base been reached by drilling in the State. Therefore, the total thickness of the formation and the character of the rock on which it rests in Illinois are not known. At Brodhead, Wisconsin, a few miles north of Winnebago County, "granite" is reported to underlie the Potsdam at a depth of 1030 feet.[1] At Delavan, Wisconsin, about 35 miles farther northeast, quartzite is known to lie below this formation, the total depth to the bottom of Potsdam being 1679 feet.[2] The maximum reported thickness of the formation in southwestern Wisconsin, location not specified, is 1200 deep.[3]

The formation outcrops over a large area in southcentral Wisconsin, the outcrops extending as far south as Madison. The Potsdam, as shown in these outcrops and in well records in Illinois, is variable in character in different places, and at different depths in the same place. In the vicinity of Madison, the Potsdam shows a well-defined calcareous shaly phase whose upper limit is 35-50 feet below the top of the formation and whose thickness is 30 feet. This has been given the rank of a separate formation and named the Mendota limestone. The 50 feet of sandstone above it also is set off from the Potsdam and named the Madison sandstone. In Minnesota and Iowa, still different phases are found and subdivision of the Potsdam, on the basis of these lithological differences as well as differences in the fossils embedded in the rock, has gone much farther. Seven different formations are there recognized.

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[1] Alden, Wm. C., Quaternary geology of southeastern Wisconsin: U. S. Geol. Survey Prof. Paper 106, p. 71, 1918.

[2] Idem

[3] Weidman and Schultz, Water supplies of Wisconsin: Wis. Geol. and Nat. Hist. Survey Bull. XXXV, p. 31, 1915.

The better records of the deep wells in Chicago show the presence of shaly and calcareous members of the Potsdam, one well showing seven or eight different phases in a thickness of about 900 feet. Since fossils commonly are not obtained in well drilling, attempted correlation of these beds with the beds known in Minnesota or Iowa is of little value. The distances between these different regions are considerable and conditions of deposition in them may easily have been different at any one time. One region may have been nearer the land; one may have had deeper water; or one may have had more vigorous waves and currents; and any such variations in conditions must perforce be recorded in the character of the sediments laid down. Thus while sand might be deposited in shallow water near shore, mud (later to become shale) might be laid down farther offshore, and in tracts where the supply of earthy material was small, the accumulation of organic remains might give rise to a calcareous deposit (later to become limestone). Furthermore, none of these conditions is permanent in any body of water, and their variation from time to time in any one place must produce differences in the sediments lain down. Nor will different regions show parallelism in the number or kind of variations, or in the time of their occurrence. It is clear, therefore, that the Potsdam sandstone may vary in many minor details in the different sections cited.

Although the name Potsdam seems destined to give place to Croixan, the original name of Potsdam sandstone has been used in this description and designates the strata, largely sandstone, which in this region lie below the definitely recognizable Prairie du Chien limestone, so far as drill holes have penetrated. The log of the Potsdam portion of well No. 8, of the Rockford municipal wells, will illustrate the variability of this formation at different depths.

Partial log of Rockford City well No. 8

Description of strata	Thickness *Feet*	Depth *Feet*
Sandstone, well rounded, colorless quartz grains	150	720
Shale, red and green	40	760
Shale, green, slightly sandy and dolomitic	30	790
Sandstone, subangular to well rounded, colorless or light yellow quartz grains	540	1330
Sandstone, chocolate in color due to cementing material, particles varying in size from a fine powder to a coarse sand	170	1500

PRAIRIE DU CHIEN ("LOWER MAGNESIAN") LIMESTONE

Immediately above the Potsdam, lies the Prairie du Chien formation, which does not outcrop within the limits of the quadrangle and is known for the region therefore only from well records. Its thickness under the city of Rockford varies from 80 to 105 feet. Such variations in the thickness are due to the existence of an unconformity, recording erosion of its surface before the next succeeding formation was deposited. The history recorded by this unconformity will be presented in chapter IV.

The Prairie du Chien, or as it was first named, Lower Magnesian, limestone outcrops in a curved belt in Wisconsin east and south and west of the area of Potsdam above noted. It also outcrops in Illinois in limited tracts in LaSalle County and along Rock River below Oregon, and northwest of Forreston in Ogle County.

Three different but closely related minerals enter into the composition of the limestones. True limestone is composed of calcium carbonate ($CaCO_3$), the mineral name for which is *calcite*. Varying amounts of impurities, such as clay, chert or flint, iron compounds, etc., are always present, but are ignored if the dominant material is calcareous. Magnesian limestone contains varying amounts of magnesium carbonate ($MgCO_3$), whose mineral name is *magnesite*. Dolomite is a calcareous rock composed chiefly of the double carbonate of calcium and magnesium ($CaMgC_2O_6$), whose mineral name also is *dolomite*. Strictly speaking, dolomite is not a limestone, but its physical properties are very similar to those of limestone and in common usage, true limestone, magnesian limestone, and dolomite are not differentiated.

The Prairie du Chien formation is a magnesian limestone, not a true dolomite. Its older name of Lower Magnesian referred to the existence of other magnesian limestones, stratigraphically higher. The formation contains a sandstone member which in some places is so thick and well marked that three formations are recognized instead of one. According to present usage in Iowa and Minnesota, the lowest member is the Oneota limestone, the intermediate beds constitute the New Richmond sandstone, and the upper member is the Shakopee limestone. "Prairie du Chien" thus becomes a group or series name. But in Wisconsin and Illinois this differentiation is not so pronounced, and the whole group or series is here considered as one formation.

ST. PETER SANDSTONE

The oldest formation which appears at the surface in Kings quadrangle is the St. Peter sandstone. Its outcrops, southwest of Paines Point near the southwest corner of the quadrangle, are part of a considerable belt of St. Peter sandstone exposed along Rock River and its tributaries, from the vicinity of Oregon to Dixon. The notable bluffs along this part of the river are composed largely of St. Peter sandstone. The sandy soil yielded by the weathering of this formation has been responsible for the only pine forest in Illinois, the "Pine Grove" near Oregon, and an isolated pine tree on a bluff of St. Peter sandstone gave the name "Pine Rock" to the township which includes the Kings quadrangle outcrops of the formation.

From the bluff known as Pine Rock, the sandstone extends eastward in a continuous cliff to Rocky Hollow, half a mile south of the Limerick School and just within the western border of the quadrangle. The upper part of the ravine called Rocky Hollow is cut in the overlying limestone, the sandstone appearing in the bottom. With descent of the valley bottom the sandstone appears higher in the walls, and at the south end of the ravine the bluffs are sandstone from bottom to top. The altitude of the contact between the St. Peter sandstone and the overlying limestone in the Hollow is about 810 feet above sea level.

An isolated hill east of the Rocky Hollow road, and three-fourths of a mile south of the lower end of the ravine is composed wholly of sandstone, except for a thin cap of limestone on the southern portion. Only flags and slabs of lime rock record the presence of this cap, and since sandstone ledges are exposed to within fifteen feet or less of the summit, whose altitude is less than 820, the limestone cap can not be more than ten feet thick.

St. Peter sandstone outcrops along the lower half mile of the stream valley immediately east of Rocky Hollow. The contact between sandstone below and limestone above is exposed on the eastern wall at the lower end of this valley at an altitude of 785 to 790 feet above sea level and opposite on the western wall at an elevation of about 800 feet. A spring issues here at the base of the limestone and flows down over the face of the sandstone.

In Rocky Hollow there is a roadside quarry in the limestone just above the sandstone. The limestone has been removed to its base, and a few feet of transitional beds are exposed here and in the channel of the adjoining creek. The section is as follows, the three middle members being transitional beds:

Limestone, probably Platteville.
Shale, blue-green, about six inches. Exposed in floor of quarry.
Sandstone, three feet.
Limestone, one to two feet.
Sandstone, St. Peter formation.

None of the other exposed contacts show transitional beds, the limestone lying directly on the sandstone.

Since the bottom of the formation is not exposed in the region, the thickness of the formation can be known only from records of the Byron city well and the deep wells of Rockford which penetrate this stratum. The Byron well and most of the Rockford wells lie not more than a mile outside the limits of the quadrangle and are as satisfactory for our purpose as though they were located within its boundaries. The drillers of the Byron well reported 380 feet of sandstone below the gravel filling of Rock

River valley and above the Prairie du Chien limestone. In the Rockford wells, the sandstone ranges from 225 to 243 feet in thickness.

The record of the Byron well is somewhat unusual. Piper and Millis, who drilled the well, report sandstone from a depth of 200 feet to a depth of 580 feet, then limestone to 640 and sandstone thence to the bottom of the well, 2000 feet below the surface. The lowest sandstone is undoubtedly Potsdam, and the limestone above is Prairie du Chien. Logically, the 380 feet of sandstone should be interpreted as St. Peter. But nowhere else in Illinois, Wisconsin, Iowa or Minnesota has the St. Peter standstone so great a thickness. The known maximum for Wisconsin is 200 feet, for Iowa 110 feet and for Illinois 325 feet. In the Byron well the St. Peter sandstone is approximately twice as thick as is known to occur generally in Illinois.

Another interpretation of the record is that the 380 feet of sandstone includes the St. Peter formation and the Shakopee and New Richmond phases of the Prairie du Chien, the calcareous beds of the Shakopee having failed of identification in the boring samples.

Evidence in favor of the second interpretation is the fact that the Byron well log has but 60 feet of Prairie du Chien limestone, while at Rockford, this formation is from 80 to 105 feet thick, and in Wisconsin its thickness in some places is more than 300 feet. The St. Peter formation thus is apparently too thick and the Prairie du Chien formation too thin, to harmonize with the facts in neighboring districts, though the sum of the two falls within the limits found elsewhere. Adopting this interpretation for the Byron well, the maximum known thickness of the St. Peter sandstone in Kings quadrangle, 243 feet, is found in a Rockford well.

The St. Peter sandstone, wherever found, is remarkably uniform in composition. It consists of clean, rounded grains of pure quartz sand, so poorly cemented that in many places it can be excavated with a spade. The cementing material is commonly silica, though locally iron oxide is present. The prevailing color is white to yellowish, the yellow color due to the iron oxide. Seams or layers of clay or of pebbles are very rare. The formation is remarkable (1) for its purity, 99 per cent quartz being not uncommon, (2) for uniformity in size of particles, and (3) for the worn and rounded character of the constituent grains.

Aside from certain exposures in the Mississippi Valley near St. Paul, where fossil shells of marine animals have been found in the St. Peter sandstone, the formation apparently is devoid of fossils. Many sandstone formations are fossiliferous, and the explanation of their paucity in this formation apparently is to be found either in the conditions under which the sand was deposited, conditions which prohibited the existence of animal life, or in its porosity and lack of cementation which would allow ground water to dissolve shells, etc., once embedded. This will be discussed in the chapter on geological history.

Note has been made of the slight degree of cementation of this formation. Yet it makes notable cliffs in most of its outcrops, cliffs which resist the attack of the weather for centuries with but little change. The sandstone in these cliffs is firmly cemented. They could not stand otherwise. But such cementation is wholly a matter of the surface part of the rock, a few inches thick. To use an expressive phrase, the rock in these outcrops is "case-hardened," a phenomenon due to the capillary flow of ground water to these surfaces, its escape there by evaporation, and the consequent precipitation of minerals it carried in solution. Cementation thereby becomes more pronounced in the surficial portion, and the rock is better able to resist the agencies of mechanical disruption to which all exposed rock is subjected.

PLATTEVILLE (TRENTON) AND GALENA LIMESTONES

Formations are correlated by means of their contained fossils across wide areas where direct tracing is impossible. It was earlier thought on this basis that a New York limestone known as the Trenton was represented in the upper Mississippi Valley by the limestone which overlies the St. Peter sandstone. Accordingly the New York name of Trenton was given to it. More careful study has shown that there are sufficient differences in the kinds of fossils in the two formations to justify the rejection of the earlier usage and to demand the application of a new name. The name "Platteville" now supersedes "Trenton" in this region.[4]

The Platteville limestone is so notably unlike the underlying St. Peter sandstone that there is no possibility of doubt about identification. This is not true however of the Platteville and the overlying formation, the Galena limestone. The fossils of the two limestones have some marked differences, but in many exposures fossils are lacking or are so few or so poorly preserved that it is not possible to differentiate the two formations on this basis. Lithologically, there are in general some differences, but they are not everywhere present. Thus in most places it is difficult to find the line of contact between the Platteville and the Galena limestones, and in many places it is impossible to determine to which of these formations the outcropping limestone belongs.

In general, the Platteville limestone is hard and brittle and breaks into thin pieces with sharp edges, while the Galena fractures with less clean surfaces and with less sharp edges. In general, the Galena limestone weathers into a yellow dolomitic sand, while the Platteville in all the known exposures in the area, is not sandy, however much weathered. In all cases, the known Galena limestone contains many chert or flint nodules distributed along the planes of stratification (see fig. 48), while the known Platteville is largely devoid of chert. Thin bedding is more characteristic of the Platteville than of the Galena (fig. 49). Irregular solution cavities, a few cubic inches in capacity, are prominent in the Galena and rare in the Platteville. The weathered surfaces of both limestones are buff to yellowish in color, but the unweathered Platteville is more likely to be gray in color, and the Galena buffish. The Platteville is more prevailingly fine-grained in appearance and is much more fossiliferous than the Galena.

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[4] Bain, H. F., Zinc and lead deposits of northwestern Illinois: U. S. Geol. Survey Bull. 246, p. 19, 1905.

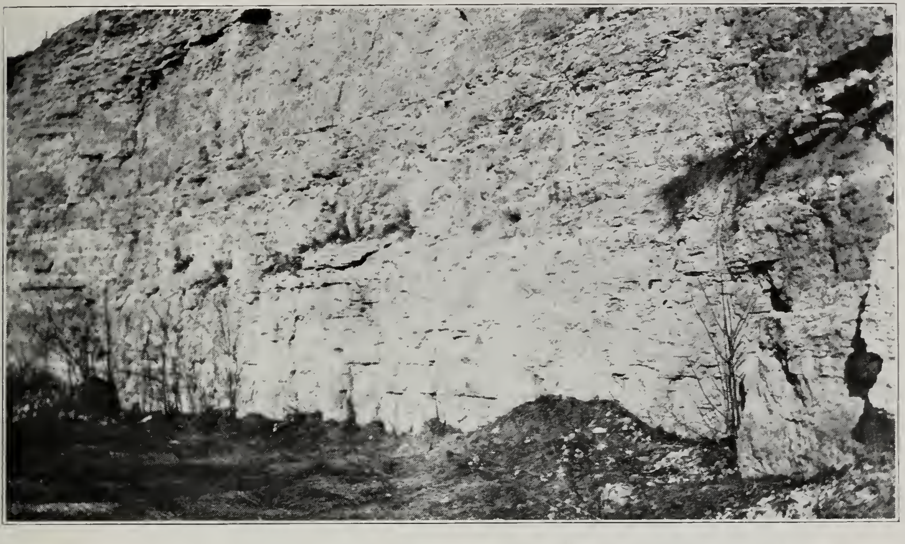

Fig. 48. Galena limestone in Carrico quarry, Rockford. Note the thin seams of chert.

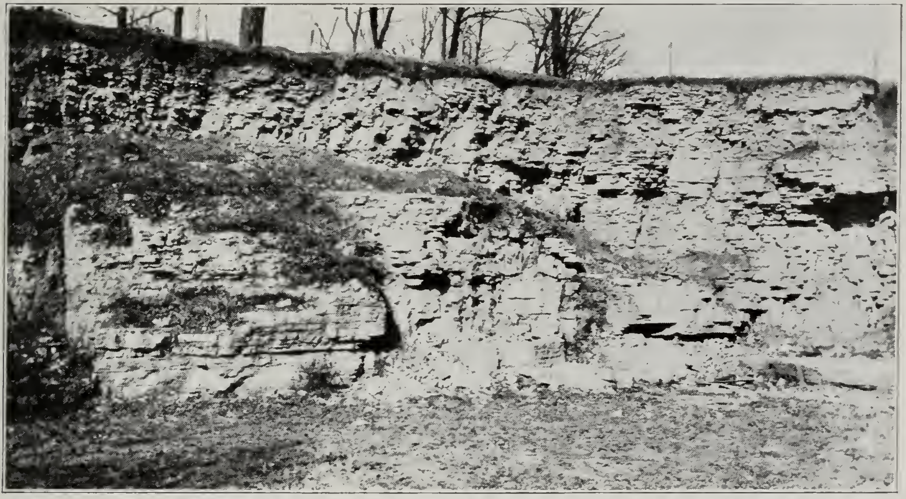

Fig. 49. Platteville limestone in quarry, 1½ miles west of Stillman Valley. Note the thin bedding.

The Galena limestone possesses a marker of unusual value in the fossil known as Receptaculites. Its value lies in its abundance, its striking character which makes it conspicuous and easy of identification, and its strict limitation to the Galena formation. Receptaculites (fig. 50), has been called "sunflower coral." The superficial resemblance of a complete disk of Receptaculites to the disk of a sunflower is striking. It also has been called the "lead sponge" because in the lead and zinc region of northwestern Illinois and southwestern Wisconsin it is often found in the Galena formation. The names "sponge" and "coral" indicate that the proper classification of this marine fossil is debatable. Its disk averaging one to two inches in thickness, is commonly six or eight inches in diameter. The fossil is most common in two definite horizons, about 70 and 200 feet respectively below the top of the Galena formation. These figures were secured from regions where the Galena is not the uppermost indurated formation, and therefore where its surface has not suffered erosion, as in Kings quadrangle. Almost every outcrop in the quadrangle which is mapped as Galena has yielded specimens of Receptaculites. Commonly it appears in the walls of the quarries and in the faces of the cliffs, and therefore in cross section. The appearance of the fossil in section, though unlike its appearance from above, is just as characteristic, and is very unlikely to be mistaken for any other form.

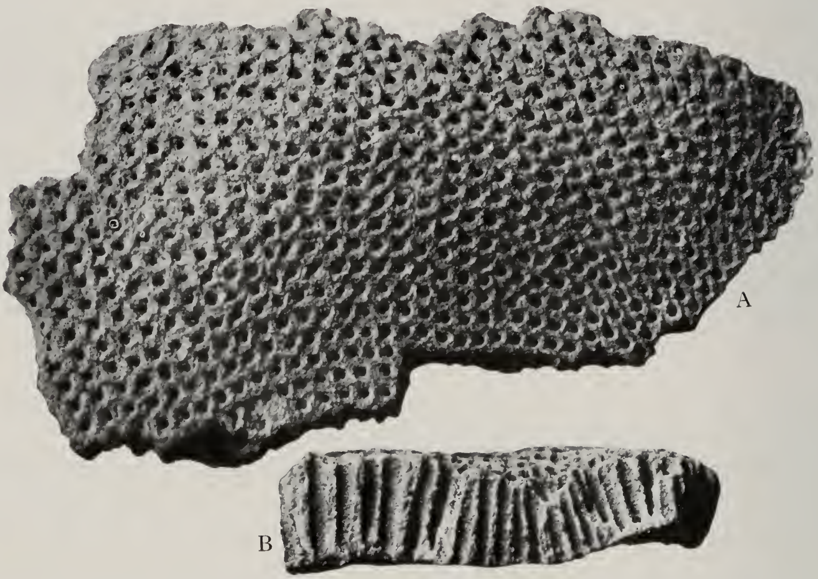

Fig. 50. Surface (A) and sectional (B) views of Receptaculities, commonly known as "sunflower coral" or "lead sponge."

Since the Galena limestone is the uppermost indurated formation of the region and has suffered considerable erosion, and since the line of contact between the Galena and Platteville has not been determined, nothing definite can be said regarding the thicknesses of either of these formations in Kings quadrangle. The thickness of the two in the present eroded condition of the upper one, however, is obtainable.

In wells drilled on high tracts where the surface of the St. Peter sandstone is known to be low, the greatest thickness of limestone still remaining over the sandstone would be found. The McCormick well three miles north of Byron, penetrated 260 feet of limestone before reaching the St. Peter sandstone. The Chicago, Milwaukee and St. Paul Railroad's well at Davis Junction was drilled into the limestone 239 feet without finding the sandstone. A well at the Wilbur School corner, one mile east of Stillman Valley, penetrated 100 feet of unindurated material and 170 feet of limestone before the sandstone was reached. Since in the hill slopes nearby, the limestone is found as high as the mouth of the well, it obviously was once present here to at least the same altitude, and this well indicates that the limestone was originally at least 270 feet thick at this point. The well on the Barrett farm, south of the junction of the Rock and Kishwaukee rivers, penetrated 250 feet of limestone before reaching the sandstone. A well in the middle of sec. 23, Byron Twp. (T. 25 N., R. 11 E.), was drilled 267 feet into limestone without reaching sandstone. And there are many wells in the quadrangle where nearly 200 feet of limestone have been found.

In the Elizabeth and Galena quadrangles, in the extreme northwestern part of the State, the aggregate thickness of the Platteville and Galena limestones is a little more than 300 feet. In southwestern Wisconsin the two formations have a maximum thickness of 350 feet. In both cases, the presence of overlying indurated strata has preserved the entire original thickness. By comparison with these figures, we conclude that in the higher regions of the northern and central portions of the quadrangle, only a few tens of feet of Galena have been lost by erosion. In the extreme southwestern part of the region, all of the Galena and the Platteville have been removed.

The Platteville formation has been identified positively only in the vicinity of Byron, but it is highly probable that it is the formation immediately overlying the St. Peter sandstone in the Limerick School region. Outcrops of limestone in the valley of Black Walnut Creek, between Byron and the Limerick School are probably Platteville, but conclusive evidence for this identification is lacking. Probably the limestone exposed near the base of the bluffs in the downstream portion of the rock-walled valley between Camp Grant and Byron is also Platteville. Elsewhere, almost every exposure of limestone in the quadrangle has yielded Receptaculites, the characteristic fossil of the Galena formation.[5] Receptaculites occurs in the lowest beds exposed in the old quarries in Blackhawk Park; it occurs in the quarries on both sides of the Kishwaukee River at the rifle range, Camp Grant; it occurs in practically every quarried outcrop north and west of Rock River as far downstream as Kennedy Bluff; it occurs in the extensive rock cut made by the Chicago Great Western Railroad west of Holcomb, and in the walls of the gorge cut by Stillman Creek in White Rock Twp., Ogle County (T. 41 N., R. 1 E.). Identification of outcrops of limestone as Galena where Receptaculites was not found, has been made on the basis of nearness to other exposures at the same altitude where the fossil has been found.

Good specimens of fossils in the outcrops of Kings quadrangle are so few that no attempt will be made in this report to describe and illustrate the various forms. Illustrative material would have to be taken from collections made outside the limits of the area studied, and it is doubtful if any one not especially acquainted with fossils in general, could identify the local material by comparison with such illustrations. The appended lists include all forms found during the field work on which this report is based, and the localities cited are almost the only ones which yield fossils, other than the widely distributed Receptaculites.

Quarry along the river road one mile north of Byron in sec. 29, T. 25 N., R. 11 E. The limestone is hard, thin-bedded, yellow to buff on joint faces, blue in certain thin layers when broken back from joint faces. It is not crumbly, nor sandy. Some strata have thin shaly partings. No chert or silica replacements occur. The general appearance is different from that of the Galena. Abundant fossil remains are found in some strata. The formation is identified as Platteville limestone.

Gastropods (snails and their allies)
    Trochonema beloitense (Whitfield)
    Salpingostoma expansum (Hall)
    Liospira vitruvia (Billings)
    Pterotheca attenuata (Hall)
    Conradella sp.
    Hyolithes baconi (Whitfield)

Pelecypods (clams and their allies)
    Whitella megambona (Whitefield)
    Vanuxemia niota (Hall)
    Vanuxemia rotundata (Hall)

Corals
    Columnaria sp.

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[5] An early account of the geology of Winnebago Co., (Shaw, Geol. Survey of Illinois, Vol. 5, 1873), states that the Platteville (there termed the Trenton) is exposed in the lower portions of the deeper quarries in Rockford. These deeper portions are no longer worked and have filled with water. Receptaculites, the index fossil for the Galena formation, has been found within four or five feet of the surface of these quarry pools. A cliff of limestone along Kent Creek in Rockford, directly opposite the Illinois Central station, is probably the lowest rock now exposed in the city or its vicinity. It was impossible to determine from the fossils collected from this cliff whether the limestone is Platteville or Galena. If Platteville, it is the top of the formation.

Cephalopods (allies of the modern squid and octopus)
  Oncoceras plebeium (Hall)

Brachiopods (bivalves superficially resembling pelecypods but with one valve unlike the other)
  Rafinesquina alternata (Emmons)
  Strophomena incurvata (Shepard)
  Orthis tricenaria (Conrad)
  Pianodema subaequata (Conrad)

Trilobites (extinct group of crustacea, allied to modern crayfish)
  Thaleops ovatus (Conrad)

Quarry a mile north of Byron and a mile west of quarry described above, located half a mile west of the boundary of the quadrangle. The rock is similar to that in quarry described above, and is identified as Platteville limestone.

Corals
  Columnaria sp.
  Streptelasma corniculum (Hall)

Brachiopods
  Rhynchotrema inaequivalve (Castelnau).

Trilobites
  Encrinurus sp.

Ostracods (crustaceans completely enclosed in bivalve shell)
  Leperditia sp.

Quarry in Stillman Creek Valley, on road between Byron and Stillman Valley, north side of creek in sec. 34, T. 25 N., R. 11 E. About thirty feet of limestone is exposed. Yellow in color on joint faces; gray on freshly broken surfaces. Very hard and brittle. Effervesces freely with acid. Identified as Platteville limestone.

Gastropods
  Hormotoma gracilia (Hall)
  Tetranota wisconsinensis (Whitfield)
  Trochonema beloitense (Whitfield)

Pelecypods
  Clionychia lamellosa (Hall)
  Whitella megambona (Whitfield)
  Vanuxemia rotundata (Hall)
  Vanuxemia niota (Hall)

Cephalopods
  Cyrtoceras sp.
  Oncoceras sp.

Corals
  Streptelasma sp.

Trilobites
  Thaleops sp.

Quarry two miles southeast of Byron in valley of Black Walnut Creek. Limestone yellow throughout, sandy, crumbling but not cavernous nor porous. One horizon with many Streptelasmas. Fine-grained, hard, splintery, mostly thin-bedded. Identified as Platteville limestone.

Brachiopods
- Orthis tricenaria (Conrad)

Corals
- Streptelasma corniculum (Hall)
- Columnaria sp.

Bluff on south side of Kent Creek, Rockford, opposite Illinois Central station. Formation not determined. Either Galena or Platteville.

Gastropods
- Liospira sp.
- Trochonema sp.

Corals
- Streptelasma corniculum (Hall)
- Streptelasma profundum (Conrad)
- Columnaria sp.

Cephalopods
- Cycloceras lesueuri (Clark)

Brachiopods
- Dalmanella testudinaria (Dalman)
- Dalmanella sp.
- Rafinesquina sp.

Unindurated Formations

PRE-ILLINOIAN GRAVEL

The oldest of the non-indurated deposits known in Kings quadrangle is a gravel with very limited exposures. Its outcrops occur in sec. 31 of Guilford Twp. (T. 44 N., R. 2 E.) and sec. 36 of Rockford Twp. (T. 43 N., R. 1 E.). The latter is the extreme southeast land section in the corporate limits of the city of Rockford. The road between these two sections is the southward continuation of Twentieth Street. There are shallow pits on both sides of this road south of the Illinois Central tracks, from which a very red-stained gravel is taken for use in the roadway. The gravel is overlain by surface loam only, and its relations here to the Illinoian till are not clear. The iron stain is virtually a cement in some layers in the gravel, so that blocks of conglomerate are broken out. These blocks are curiously cavernous. No gravel would ever be deposited with cavities among the pebbles as large as these, and they must owe their origin to changes subsequent to deposition. The heavy ferruginous stain and the amount of decay in the pebbles themselves indicate a great amount of weathering, and it seems very likely that the cavities record the former presence of limestone pebbles which have been removed entirely by the leaching of ground water while the weathering was in progress.

A large abandoned gravel pit in sec. 31, T. 44 N., R. 2 E., an eighth of a mile east of the road and on the east side of the Chicago and North Western Railway tracks, has a partially cemented ledge of this red decayed gravel exposed in the bottom. The gravel contains granite, greenstone and other foreign material and its limestone pebbles are etched and corroded. Overlying the gravel is a gray pebbly till which immediately above the decayed gravel effervesces freely with acid.

The till is without question the Illinoian. The weathered character and the position of the gravel beneath the unweathered till seem to indicate that the gravel was exposed to the action of the atmosphere for a long time before the upper formation was laid down. Indeed, the upper surface of the Illinoian till is in few places weathered to a comparable extent.

In the cut along the Illinois Central Railroad just west of the abandoned gravel pit, the same relationship is shown between the overlying Illinoian till and an underlying gravel. In this cut, the red-stained gravel has an irregular upper surface, several knobs projecting a few feet up into the till. These were earlier interpreted as boulders of the old gravel[6] incorporated in the overlying till. Excavation with a spade about these supposed boulders of red-stained, ferruginous, cemented gravel shows them to be but more firmly indurated portions of a continuous deposit of the old gravel beneath the fawn-colored to pinkish-gray Illinoian till. The greater induration explains the prominence of the projections into the till. Excavation revealed that the unwashed, typical till rests on the well-washed stratified gravel, the contrast in color accompanying the contrast in amount of sorting. There is also the contrast in calcareous content noted for the other exposures, the till being highly effervescent, whereas if the orange-colored gravel showed any effervesence, it was very slight.

If there were boulders of the red gravel in the overlying till, it would be perfectly clear that the gravel existed as a stained and cemented formation at the time the Illinoian ice sheet invaded the region, and that the overriding ice incorporated bouldery fragments of the gravel in its till, just as it did from the underlying Galena and Platteville limestones. But without this evidence, it is conceivable that the underlying gravel might be a deposit of waters escaping from the advancing Illinoian ice, later overridden by the glacier and covered with till, and in post-Illinoian time stained and cemented by ground water. There would be much freer circulation through the gravel, and staining, leaching and cementing therefore might far exceed that in the less pervious till above.

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[6] Leverett, Frank, The Illinois Glacial Lobe: U. S. Geol. Survey Mon. 38, p. 109, 1899.

To settle this question and establish conclusively, if possible, that the weathering of the gravel occurred before the till was deposited, excavation was carried farther, and the search was rewarded by finding small fragments of the cemented gravel in the lower few inches of the till, and entirely surrounded by the material of the unweathered till. Though the case of "boulders in till" is in error, the same kind of evidence has been found, and the gravel is definitely known to have been weathered and cemented before the till was deposited.

It is interesting to note that the most conspicuous knob of pre-Illinoian gravel exposed in the Illinois Central cut shows inclined stratification. This was first taken as good evidence that the knob was a boulder or fragment which had been moved and tilted from an original horizontality. But it must be remembered that gravel is in many cases deposited in inclined layers. If these inclined strata in the pre-Illinoian gravel are not steeper than 25°, as was found to be true, it would remain a possibility that they were deposited in the position now found. The further evidence secured by digging shows this to be the correct explanation.

More recent work by M. M. Leighton has resulted in the finding of gravel under Illinoian till on the west side of the valley in the city of Rockford, about three blocks west of the junction of the forks of Kent Creek, at an elevation of about 750 feet above sea level. The till rests on unleached gravel and therefore is no evidence that a time interval existed between the deposition of the two, although the Illinoian ice may have removed the weathered zone. Dr. Leighton also found gravel, much weathered, exposed at about the same level southwest of Rockford in T. 43 N., R. 1 E., at the following places: (1) in a pit west of the angling road in the SE. ¼ sec. 4; (2) in a pit north of the east-west road at the SE. cor. of the same section; (3) in the NW. ¼ NE. ¼ sec. 9; and (4) along the upper part of the slope in the NW. ¼ sec. 16. In these places no till was seen to overlie the gravel, but the outcrops are on slopes favorably situated for erosion to have removed the till. On the east side of the Rock River Valley there are numerous exposures of Illinoian till overlying gravel at about the 760-foot level immediately south of Rockford, and at elevations above this, north of Rockford. In some places it seems clear that the gravel is pre-Illinoian glacial outwash or a valley train.

OTHER PRE-ILLINOIAN PLEISTOCENE DEPOSITS

No other outcrops of Pleistocene deposits older than the Illinoian till are known for the region, but several well records note the occurrence of muck, wood and "coal" beneath the Illinoian till in various localities in the quadrangle. One of these is located on the farm of Tom Bishop in sec. 9 of Marion Twp. (T. 24 N., R. 11 E.), about 3½ miles south of Byron. The well was dug years ago to a depth of 60 feet through clay and "hardpan" (glacial till). At the bottom, a tree stump was dug out. More recently, when the well was deepened by drilling, bits of wood were brought up in the operations and rock was found ten feet below the bottom of the original dug well.

Another occurrence of the same character is the well of Ted Evans in New Milford. A log, fragments of which have been kept by the driller, was encountered in drilling this well. The log was 80 feet below the surface and the material above it was Illinoin till. Another occurrence of vegetal matter in a well was reported a mile west of the village of White Rock. This well was dug many years ago and no definite data are now available. It is only known that "coal" was reported to have been found.

ILLINOIAN DRIFT

ILLINOIAN TILL SHEET

As shown on Plate IV, the Illinoian till underlies most of the area now covered by later deposits. Theoretically, it originally covered the whole region.

Local conditions, both at the time of deposition and during subsequent time, account for the exceedingly variable thickness of the two till sheets. Prominent rock hills carry the minimum original thickness; pre-existing valleys contain the maximum thickness. Well records show this strikingly. As an illustration, the high region about Kings station may be cited. The records of 32 wells within three miles of this village and within the limits of the quadrangle were secured. The wells all penetrate Illinoian till and most of them go through the till into the underlying Galena limestone. In these wells, rock was found as follows:

Depth below the surface *Feet*	No. of wells
5	1
6	1
7	3
8	2
9	1
10	4
11	1
12	3
14	1
16	1
18	4
20	3
25	1
30	1
36	1
40	1

The average thickness of the till sheet on this broad, flat divide therefore may be estimated as 15 feet. It is to be noted, however, that this thin cover is almost continuous for the whole area. Only two small tracts have bedrock exposed and in one of these, the exposure is clearly due to recent valley cutting.

In contrast with the above figures from an upland tract are the well records in the broader valleys. From Rockford southward to the southeast corner of the quadrangle is a low area now occupied in different portions by Rock River, Kishwaukee River, and Killbuck Creek. Along this 18-mile line is an area two miles wide, in which most wells penetrate only unconsolidated materials. Where rock has been found in the drilling, it is at a surprisingly great depth.

The well of the Rockford Malleable Iron Works, situated within the limits of this quadrangle, penetrated 286 feet of sand and gravel before reaching rock. That at Fire Station No. 4, in the same part of the city, reached rock 300 feet below the surface.[7] The altitude at the mouth of these wells is about 740 feet above sea level. The upper 40 feet in these wells is Wisconsin outwash, younger than either of the drifts. Rock was not reached in the Camp Grant wells having a maximum depth of 185 feet, nor in a well 168 feet deep at Mr. Corlet's farm, just west of the Chicago, Milwaukee, and Gary Railroad tracks a mile south of New Milford. Along the Meridian Highway between New Milford and Davis Junction, all wells end in gravel at depths which average about 100 feet. A well a mile and a half east of Davis Junction is 165 feet deep and does not reach rock. Half a mile farther east is a 200-foot well, in the drilling of which no rock was encountered. Another 200-foot well without rock lies a mile south of the last, and still another a mile east of the Beacon School is 200 feet deep, in drift. A well just off the edge of the quadrangle, east of the Moore School, is 100 feet deep and does not reach bed rock.

The material penetrated in drilling these wells is reported in the general terms of "sand, clay, and gravel". It would be unsafe to assume that it all belonged to the Early Wisconsin and the Illinoian till and associated gravel, for this remarkably low tract in the bed rock surface probably contains pre-Illinois Pleistocene deposits. But the till is doubtless several times as thick here as on the uplands. The meaning of this notable linear depression in the surface of the indurated formations will be discussed in the chapter on geological history.

The composition of the Illinoian till has been described already in a general way. The major constituents are clay and silt, with which quartz sand in less abundance is intimately mixed. Pebbles and cobbles are scattered throughout and a few boulders are present in the body of the till. The boulders are rare, however, compared with the other constituents. Mineralogically, the unaltered till contains more calcareous debris ranging from the finest rock flour to boulders than all other materials together. Much of it was derived from the underlying Galena limestone, and the remainder was brought into the region from outcrops of the younger Niagaran limestone to the northeast. The Niagaran underlies the glacial drift from Lake Michigan as far west as DeKalb, Sycamore, Marengo, Harvard, and underlies a corresponding area in southeastern Wisconsin. Glacial ice advancing from any point between northeast and east had to traverse this wide belt. Debris from igneous rocks, which is distinctly foreign material, is recognizable of course only in pebbles, cobbles and boulders. Though conspicuous because of its unlikeness to the predominating material, its proportion is small.

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[7] Information from Andrew Johnson, a well driller at Rockford, corroborated by Paul Millis, well driller at Byron.

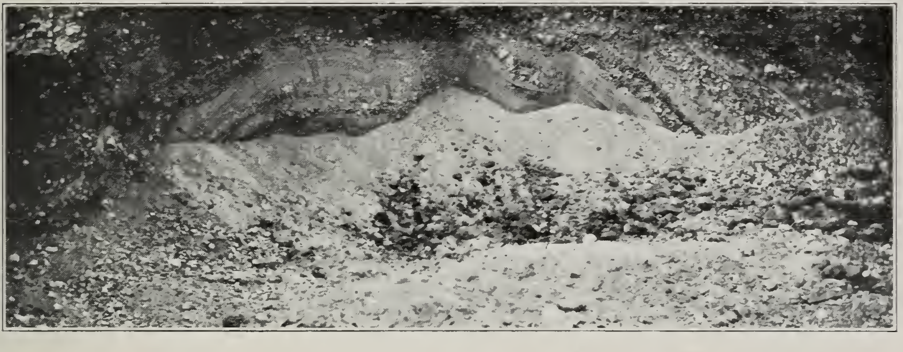

Fig. 51. Inclined stratification in kame gravel, sec. 6, Cherry Valley Twp., Winnebago County.

The color of the Illinoian till varies with depth, grading from a rusty red at the surface to a buff or fawn color at ten or fifteen feet below the surface and at greater depths, a blue-gray. This gradation in color is the result of weathering, the lighter colored calcareous constituents having been dissolved out of the upper few feet, and the associated iron-bearing minerals having been oxidized to produce the rusty color.

A GRAVEL DEPOSIT SHOWING DEFORMED STRATIFICATION

A deposit of gravel on the east valley slope of Rock River, in the eastern half of Camp Grant, shows some interesting deformed stratification. A pit in the NW. cor. sec. 6, Cherry Valley Twp., (T. 43 N., R. 2 E.) Winnebago County, shows the material which is photographed in figure 51. The picture is a bit deceptive, for the excavation has produced a semi-circular cut bank, causing the two sides in the view to be nearer the observer than the middle. There is not, therefore, as notable an arching of the strata as appears in the picture. The dip, however, does diverge somewhat on the two sides of the excavation. In the center the dip is toward the observer and hence does not show in the figure. The maximum dip of 39° is in the direction in which the spur points, away from the higher land.

This structure theoretically is just what should exist if the gravelly spurs originated as delta fingers; that is, successive additions to the delta should be carried across that already accumulated and dropped at the far edge where it would slide off to take the angle of rest under water. This procedure produces the *fore-set beds* of deltas, dipping toward the body of water in which they were deposited. But such fore-set beds are seldom steeper than 25°, and these have a maximum dip of 39°. Furthermore, they are somewhat distorted in a minor way. It is probable that there was some movement of the ice against the gravel deposit after its accumulation, and that this produced the distortion and steepening of dip.

The gravel in the upper portion of this pit is stained yellow by iron oxide, and portions are cemented by calcium carbonate. So great is the coherence that large masses have been left on the floor of the pit like so many boulders of indurated rock.

LOESS AND LOESS-LIKE LOAM

There is a mantle of loam which generally covers the Illinoian drift of the Kings quadrangle. It is fine-textured, brownish, usually non-calcareous in the exposures, and virtually free from pebbles except near the contact with the underlying till, where a few scattering pebbles may be found. It is commonly unstratified. According to Leighton[8], where the deposit is sufficiently thick, the base was found by auger borings to be calcareous and in some instances to contain fossil snail shells. The underlying till, however, is leached for a few feet. The material is called loess in such cases and is doubtess wind-blown. But where the deposit is thin, some of the material may be aeolian and some may be the result of the work of small burrowing animals which bring fine earthy matter to the surface from below. Earthworms are known to bring large quantities of fine material to the surface, where they void it in their castings. The accumulations of such work might well yield a considerable mantle of such material, though it never would become deeper than the lower limit to which earthworms work. Ants also bring up fine materials, but they handle particles in their mandibles and thus would collect considerable coarse sand, which is not common in the deposit. In such thick deposits where its origin is indeterminable the material is commonly called loess-like loam. Its contact with underlying gravel is clear evidence that it is not a product of decomposition of underlying material.

The deposit is generally thicker on broad hill-tops and at the base of slopes than on slopes, and thicker on the Illinoian than on the Early Wisconsin. Twenty-nine borings, made by Leighton, in the Illinoian portion

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[8] Some of the material presented here is based upon the manuscript of two papers read by Dr. Leighton before the Geological Society of America: (1) "Illinoian and Post-Illinoian drift in northern Illinois, west of the mapped Wisconsin moraine," Chicago meeting, December, 1920, and (2) "Further data on the differentiation of the glacial drift of northern Illinois," Amherst meeting, December, 1921. Abstracts of these appear in the bulletins of the Geological Society of America.

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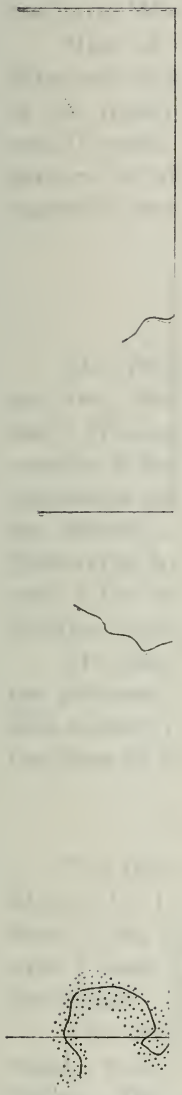

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of this quadrangle showed an average thickness of 4.7 feet; whereas, thirty-four borings on the Early Wisconsin showed an average thickness of 2.2 feet. Surface boulders are more numerous in the Early Wisconsin area than in the Illinoian, due probably to the thinner loess mantle. The maximum thickness which was penetrated on the Illinoian was 9 feet, while that on the Early Wisconsin was 7 feet.

Most of the loess of the Mississippi Valley is post-Illinoian and pre-Wisconsin in age. Because no younger formation overlies the loess-like loam in this region, its age is not definitely determinable, other than that it is post-Illinoian. Some of it is younger than the Wisconsin valley train, on portions of which it lies. It may well have been accumulating in the ways suggested ever since the retreat of the Illinoian ice.

WISCONSIN DRIFT

DEPOSITS WITHIN THE QUADRANGLE

The Wisconsin drift of the Mississippi Valley region is subdivisible into two, the Early Wisconsin drift and the Late Wisconsin drift. The Early Wisconsin drift comprises several moraines, of which the Shelbyville moraine is the oldest and the Bloomington moraine the next oldest. In this quadrangle the Early Wisconsin drift is represented by what has been named the Belvidere lobe, which according to Leighton is the correlative of the Shelbyville drift. The Bloomington does not enter this quadrangle, but lies only a few miles to the east, as shown in Plate VI. Outwash from this moraine, however, is present in the quadrangle along Killbuck Creek.

The Late Wisconsin drift is represented, not by till sheets which record the presence of glacial ice, but by outwash deposits along the Rock and Kishwaukee valleys which came from the Green Bay and Delavan lobes of the State of Wisconsin.

EARLY WISCONSIN DRIFT

The following discussion of the Early Wisconsin drift was written by Morris M. Leighton of the Illinois Geological Survey, who has made a study of the drift west of the Bloomington moraine and the Marengo Ridge over a much larger area than that included within the limits of the Kings quadrangle.

The Belvidere lobe of Early Wisconsin age extends into this quadrangle, reaching a point about one mile west of the village of Stillman Valley. The northern boundary of the lobe enters the quadrangle near the elbow turn of the Kishwaukee Valley and leaves the quadrangle about three and a half miles west of the southeastern corner. No moraine marks the extreme limit, but from one to three miles within the boundary is a morainic belt which is fairly persistent save for a stretch about three miles in length to the east and northeast of Kings. Big Mound, northwest of Holcomb, the tract of gravel hills northwest of Davis Junction, and those west of Harrisville, in sec. 31, T. 43 N., R. 2 E., and to the southwest in sec. 1, T. 42 N., R. 2 E., are in this belt. Beyond this on the southwest side of the lobe, the boundary is drawn chiefly on the basis of a smoother topography and of auger borings and exposures which show fresher drift to the east and north than to the west and south. North of Stillman Valley the boundary was drawn to include the considerable gravelly tract and here the area shows some glacial undulations and a smoothing effect of the topography, apparently due to glaciation, although the drift is thin and the rock is close to the surface.

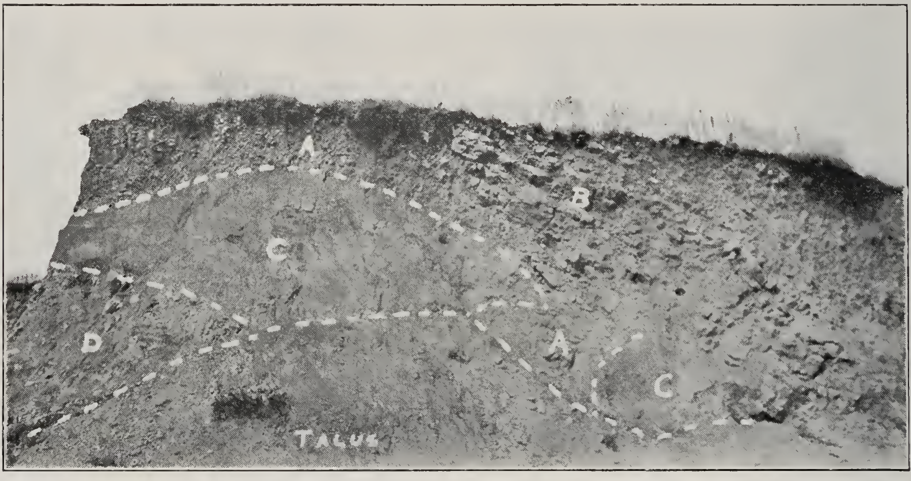

Fig. 52. Tilted ledges of Galena dolomite thrust upon fossiliferous loess in quarry, sec. 20, T. 43N., R. 1E.

Since the publication of the map, the boundary of the lobe has been extended in the vicinity of the Kishwaukee School to include the smooth southeastern slope of the hill in secs. 20, 21, 28, and 29, T. 43 N., R. 1 E., and a quarry exposure at the summit just west of the fork of the roads near the south line of sec. 20. The recent opening of this quarry for road material revealed tilted ledges of Galena dolomite thrust upon fossiliferous loess, as shown in figure 52. The Galena dips at an angle of 38° in the direction of 14° east of south, indicating ice thrust from that direction, in harmony with the radial movement of the lobe. The underlying loess is yellowish to brownish yellow, calcareous, and floury. Most of the fossils are broken as the result of the ice thrust, but from a collection made from the place marked C in the photograph, Frank C. Baker, Curator, of the University of Illinois Museum, has identified four species: *Pyramidula shimekii, Succinea grosvenari, Helicina occulta,* and *Bifidaria* (sp. undetermined). These have the aspect of being Early Peorian in age, and hence the movement is referred to the Early Wisconsin ice.

The revised boundary is also in harmony with the youthful gorge immediately beyond, which is more youthful than the rest of the Rock River Valley below Byron.

DIFFERENCES BETWEEN THE EARLY WISCONSIN AND THE ILLINOIAN

The criteria for differentiating this lobe from the Illinoian drift were, as has been stated, worked out by the study of a much larger area than the Kings quadrangle, although they all apply to this area. They embrace: (1) differences in amount of erosion; (2) differences in the depth of leaching; (3) differences in the degree and depth of oxidation; (4) differences in the amount of decomposition; (5) differences in the relations of the overlying loess to the underlying till; (6) differences in the sequence of materials overlying the till; (7) differences in the thickness of the loess; and (8) changes in drainage.

1. *Differences in amount of erosion.*—The topography of the Belvidere Lobe shows a fresher glacial aspect and poorer drainage development than the Illinoian area to the west. In making this comparison, the fact must not be overlooked that the erosional topography of the Illinoian is inherited to a considerable degree from pre-glacial times, for the Illinoian drift is a thin mantle over the eroded bedrock surface. However, the minor drainage lines of the Illinoian have etched themselves into the slopes and destroyed most of the glacial features which would be expected if the mantling had been recent, and where there are morainic belts of considerable magnitude they are subdued as compared with the fresher contours of the morainic features of the Belvidere Lobe. Killbuck Creek valley is poorly developed, compared with known valleys of similar drainage area and gradient in the Illinoian area.

2. *Differences in depth of leaching.*—Within this quadrangle, 29 borings in the Illinoian area revealed an average of 7.9 feet of leaching, including one foot of soil, 3.7 feet of leached loess, and 3.2 feet of leached till. In the Early Wisconsin of the quadrangle, 34 borings averaged 4.4 feet of leaching, of which 1.3 feet was soil, 1.4 feet leached loess, and 1.7 feet leached till. The number of borings which revealed a given depth of leaching is shown graphically in figure 53. Of the 29 borings in the Illinoian area, 18 borings, or 62 per cent, did not pass through the leached zone or struck rock without reaching calcareous till. Of the 34 borings in the Early Wisconsin, only five borings, or less than 15 per cent, did not reach calcareous till.

3. *Differences in the degree and depth of oxidation.*—Some road-cut exposures of the Illinoian till show a brown to rusty brown color in the upper one to two feet, whereas in the Early Wisconsin area these colors, which are indicative of a long period of weathering, are absent except in loose sands, the prevailing color being buff to yellowish buff. In the Great Western Railway cut through the morainic ridge about one mile northwest of Holcomb, some sand lenses at the top are reddish brown, but the till is buff at the top changing through yellow to gray at a depth of seven or eight feet from the surface where the oxidation is slight. Oxidation in the Illinoian commonly reaches depths of 12 or 15 feet or more.

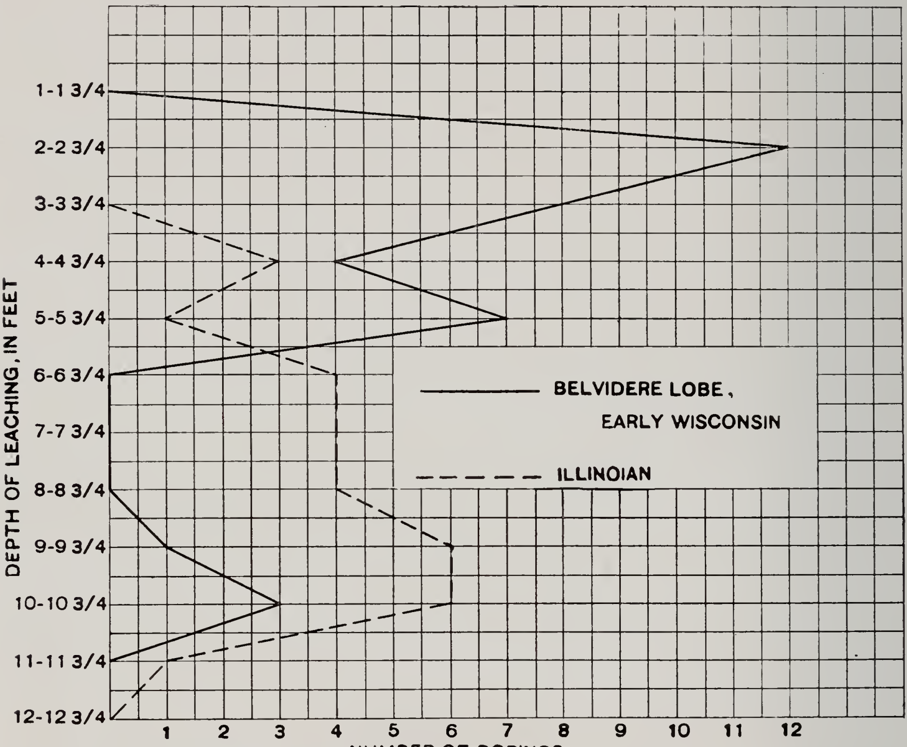

Fig. 53. A diagram showing graphically the number of borings in the Belvidere Lobe and the Illinoian are which revealed a given depth of leaching. Twenty-four borings or 70.6 per cent of the total in the Belvidere area showed a leaching of 2 to 4¾ feet, while 29 borings or 86.2 per cent in the Illinoian area showed a leaching of 6 to 11 feet.

4. *Differences in the amount of decomposition.*—Exposures of gumbotil occur in the Illinoian area, whereas none are known in the Early Wisconsin area. This substance is a gray to brownish gray clay, tenacious when wet, hard when dry, checks on dry surface, contains only small siliceous pebbles seldom larger than half an inch in diameter, exhibits "pit and pellet" texture on fracture surfaces, and is thoroughly leached. It

resembles the gumbotil which occurs on the Illinoian, Kansan, and Sub-Aftonian drifts of Iowa, and which Geo. F. Kay and J. Newton Pearce[9] have shown to be the product of prolonged chemical decomposition of the upper part of the till. Exposures in this quadrangle are found along the roadside in the SW. ¼ sec. 35 and just north of the center of the east line of sec. 36, both in T. 24 N., R. 11 E. Another outcrop also occurs about three-fourths of a mile west of this quadrangle along the south line of the southeast quarter of sec. 31, T. 24 N., R. 11 E. Its absence in the Early Wisconsin area is consistent with the other evidences which indicate a difference in the age of the drifts of the two areas.

5. *Differences in the relations of the overlying loess to the underlying till.*—In the Illinoian area where the loess is thick enough to be calcareous, it generally rests on leached and oxidized till, showing that the till was exposed to weathering for a long time before the loess was deposited. In the Early Wisconsin area, in three borings which showed the base of the loess to be calcareous, the upper part of the underlying till is calcareous and contains limestone pebbles, indicating that the deposition of the loess followed immediately the deposition of the till.

6. *Differences in the sequence of materials overlying the till.*—The yellow loess of the Illinoian area is separated from the underlying till in some places by an odorous humus layer, evidently an old soil and in others by a brownish gray loess-like silt which contains minute manganese pellets, and which is invariably leached even though it is overlain by calcareous loess. This sequence from bottom to top, of till, old loess or soil or both, and yellow loess was not encountered in the Belvidere Lobe.

7. *Differences in the thickness of the loess.*—As has been mentioned previously, the loess on the Illinoian drift is generally thicker than the loess-like film on the Early Wisconsin drift. The variation in the thickness of the loess, however, makes this criterion indecisive.

8. *Changes in drainage.*—The Kishwaukee gorge is difficult to explain on the basis of the Illinoian invasion, for in general the front of that ice retreated from west to east, and the low pass east of Harrisville could not have been uncovered when the Kishwaukee first cut across the divide to the north. The youthful character of the Rock River gorge above Byron is also in harmony with the conception of a Post-Illinoian ice invasion.

In view of these convergent lines of evidence it would be unscientific to group the two areas together even though the line between is not marked by a definite moraine.

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[9] Kay, Geo. F., and Pearce, J. Newton, The origin of gumbotil: Journal of Geology, Vol. XXVIII, No. 2, pp. 89-125, 1920.

COMPOSITION OF THE DRIFT

The composition of the Early Wisconsin drift is not noticeably different from that of the Illinoian immediately to the west. There are at least two reasons for this. Both ice sheets traversed much the same bedrock formations, and some of the Illinoian drift was incorporated into the Early Wisconsin.

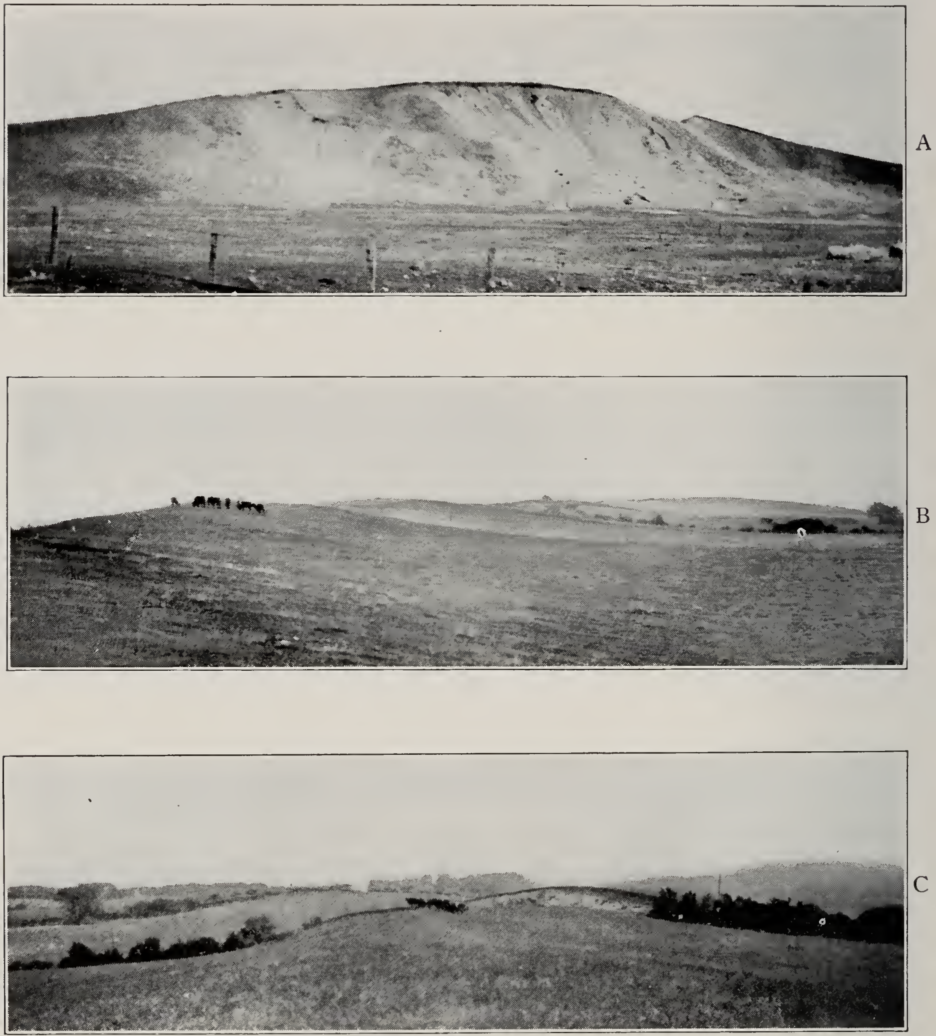

Fig. 54. Views of the central ridge of the Stillman Valley eskerine tract.
A. Large pit at the west end. The sky line is a cross section profile of the ridge.
B. Near eastern end of the ridge.
C. Near crossing of north-south road. Cut bank of roadside pit is shown.

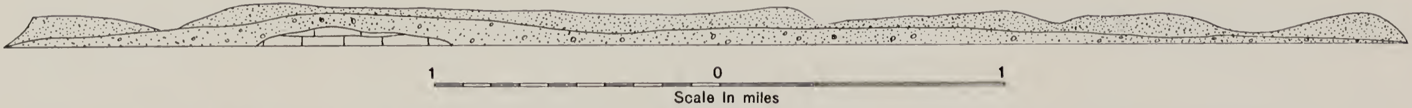

Fig. 55. Diagrammatic longitudinal section of the central ridge in Stillman Valley eskerine tract. Note the profile of the crest of the gravelly ridge and that of the limestone beneath the till. The profile of the surface of the till below the gravel is by inference the same as that of the adjacent moraine.

EARLY WISCONSIN GRAVEL DEPOSITS

Lying on the Early Wisconsin till but virtually contemporaneous with it are several gravelly tracts in Kings quadrangle. The gravel occurring in hills or hillocks higher than the surrounding till, is clearly glacial drift, but its stratification, its lack of finer constituents, and its segregation into hilly tracts indicate that it was not deposited by glacial ice alone.

Stillman Valley Eskerine Tract.—The largest and most complex group of gravelly hills and ridges in Kings quadrangle lies north and northeast of the village of Stillman Valley. It extends from Little Mound, overlooking the Kishwaukee Flats, to the group of striking gravel knolls a mile north of the village named, thus extending across the divide between Kishwaukee River and Stillman Creek. One main central ridge (fig. 54), heading in Little Mound, and traceable almost continuously across the tract, is flanked by two groups of shorter ridges, sub-parallel to it, but breaking up southwestward into numerous finger-like diverging spurs which terminate abruptly in the north slope of the creek valley.

The central ridge, a little more than two miles long (fig. 55) and nowhere more than 50 feet above its immediate surroundings shows variability in height due to an undulating crest and variations in altitude of the subjacent land. It is highest at the extremities and is inconspicuous between. In general, its slopes are steeper than those of the surrounding surfaces, but they are nowhere more than 15°. Such a slope looks much steeper in the landscape than on a sectional representation, as figure 56.

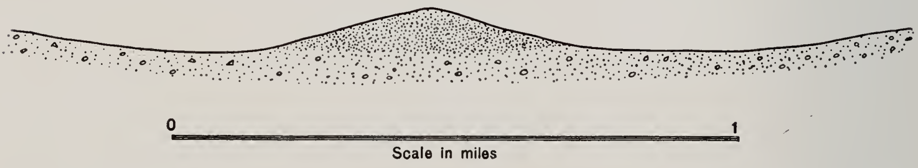

Fig. 56. Diagrammatic cross section of the central ridge in Stillman Valley eskerine tract. Near eastern extremity. Bounded by portions of the Kishwaukee Flats. The slope of the ridge is 15° whereas that of the neighboring hills is 7½°.

Of the two flanking groups of gravel hills, the western one is the more striking. It splits up into not less than thirteen short spurs, diverging through a complete half circle, from east through south around to west. The pattern is roughly like that of the ribs of a folding fan whose handle lies to the north. From the south these spurs appear as steep knolls, rising above the floor of Stillman Creek valley. Several of the spurs have knoll-like summits, but it is clear that all are connected as one group of radiating ridges. Though the slopes of these knolls are considerably steeper than those of the adjoining glacial till, they do not exceed 15°.

The eastern group is patterned like the western, but the branching finger-like termini are fewer, longer and generally not so conspicuous.

In most places, the depth of the gravel in these ridges is equal to the height of the knolls. The largest of the many pits opened in the area is located at the western end of the central ridge where the removal of material has left a cliff 50 feet high, exposing only gravel and sand from bottom to top. The ridges rest largely on till. In but one place is the gravel known to lie on limestone.

These ridges are wholly unlike stream divides, and the enclosed lower tracts are not stream-eroded valleys, even though some of them do possess drainage lines. Such gravelly ridges were *built up* where they stand, and the associated valleys are simply the unfilled tracts. The ridges are constructional, not erosional, features. Appreciation of this point is essential to an understanding of their origin.

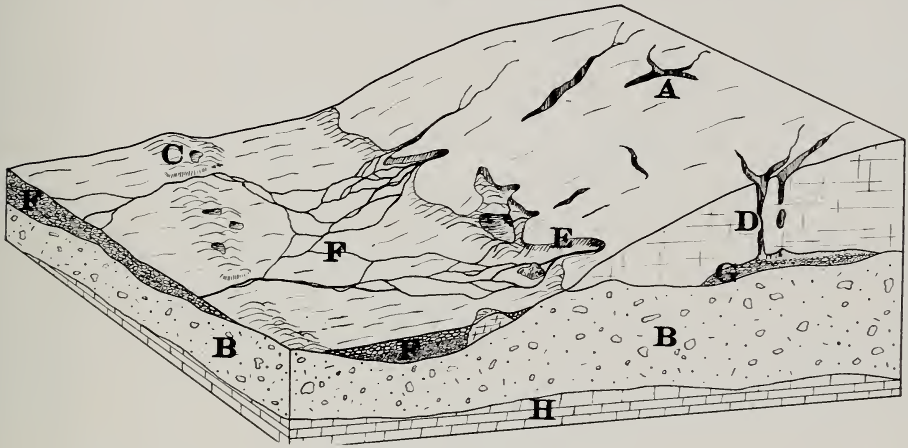

Fig. 57. Block diagram to show the margin of a retreating glacier.
A. Glacial ice.
B. Ground moraine deposited by glacial ice.
C. Ridged drift or marginal moraine, abandoned by retreat of the ice. Similar ridged drift is shown at and under the existing edge of the ice.
D. Super-glacial streams descending to become sub-glacial.
E. Sub-glacial stream emerging from tunnel, a situation where kames are formed.
F. Outwash plain deposited by heavily loaded fluvio-glacial streams.
G. Fluvio-glacial deposits under the ice. These may give rise to eskers after melting of the ice.
H. Bed rock.

Two other significant facts, bearing on the question of their origin, are (1) their composition of gravel and sand, and (2) their diverging habit.

The gravel contains as large a proportion of foreign rock-debris as the glacial till beneath it, and presumably therefore is related to glaciation. But it is stratified, and it contains very little clayey material; in both of these features differing from deposits left by glacial ice, and resembling deposits of running water. Since there is much running water associated with glaciers, it is logical to think of these gravelly accumulations as the product of streams originating from melting glacial ice (fig. 57).

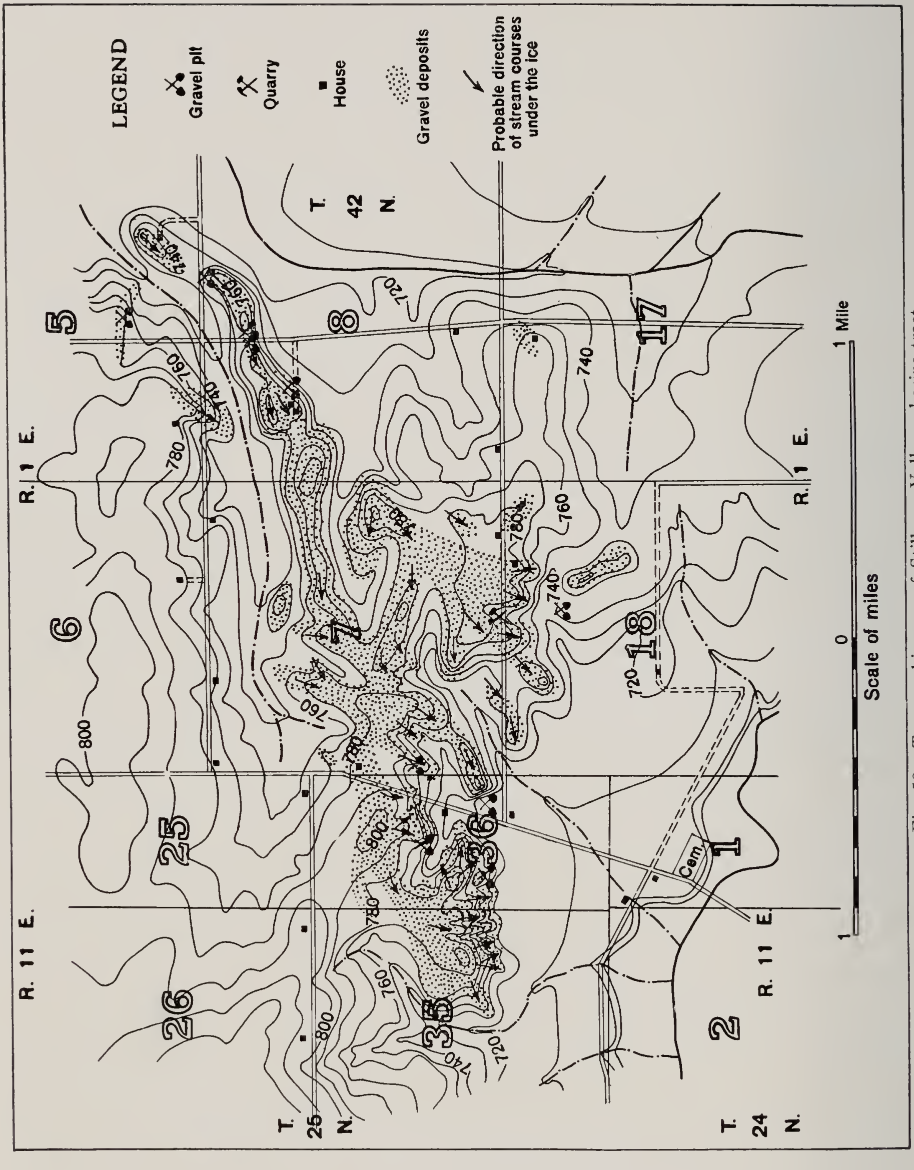

Fig. 58. Topographic map of Stillman Valley eskerine tract.

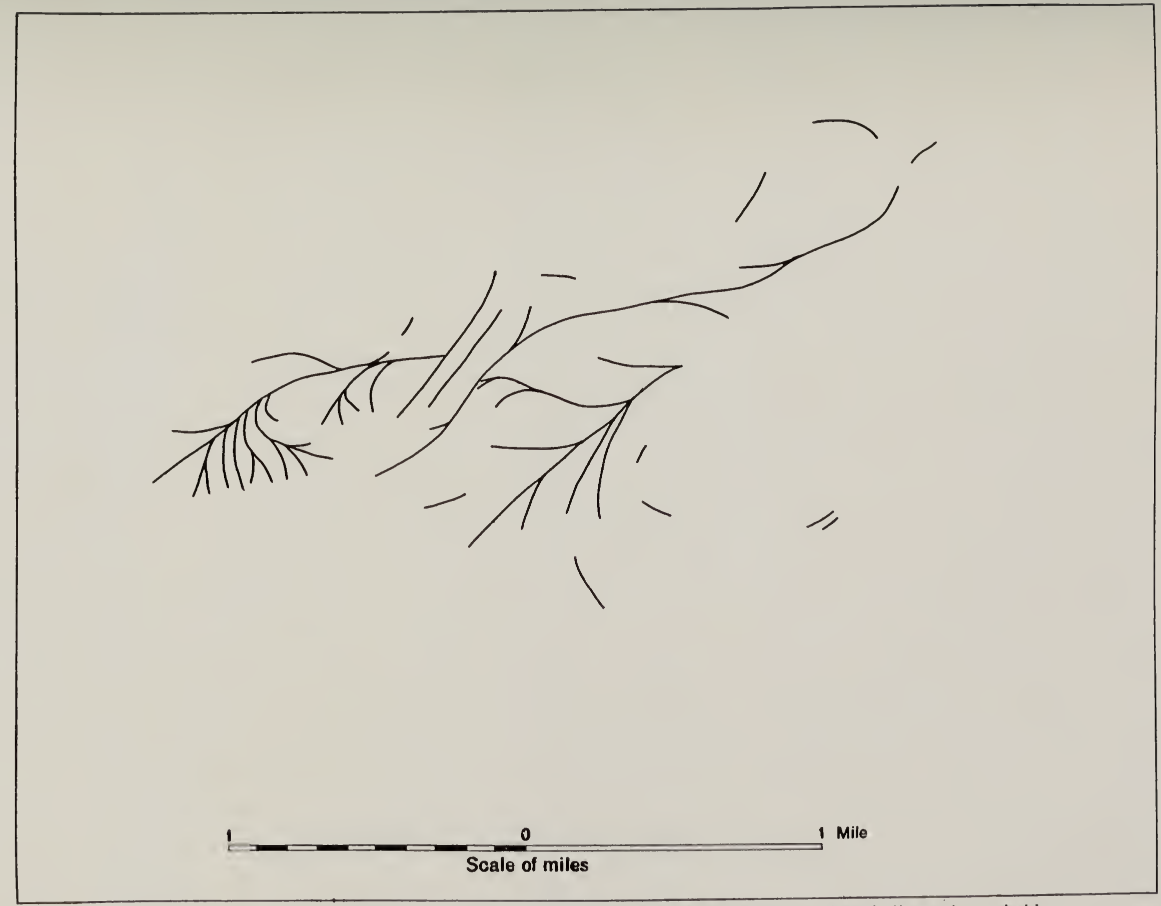

Fig. 59. Crest lines of the gravelly ridges in the Stillman Valley eskerine tract. These indicate the probable pattern of the sub-glacial drainage which deposited the ridges.

Now, a glacier melts not only at the front edge, but over a broad zone on the surface back from the front. The water from this melting ice flows in channels on the glacier until it reaches the edge, or until it encounters a crevasse where it plunges to lower levels. Enlargement of such crevasses by the descending water will finally determine a drainage system deep within the ice near the glacier's margin. In some existing glaciers, streams emerge full-grown from tunnels at the glacier front, and they can be heard roaring along their subglacial courses for some distance back from the front.

Such streams of high velocity and of corresponding carrying power, have exceptional opportunity to acquire debris as they flow through the lower portions of the glacier. Glacier-born streams are perhaps the most heavily laden of all streams. The material carried is, of course, of glacial origin, and in the case of the ice sheet which once invaded this part of Illinois, some debris from Canadian granite and other deep-seated rocks is present. The subglacial streams are abruptly checked as they emerge from their tunnels and deposition of the coarser debris ensues, the deposits accumulating much as alluvial fans are built by ordinary streams when velocity is notably lessened by decrease in gradient. The slackening in current may extend back up the tunnels for some distance causing stream gravels to be deposited in these ice-walled courses.

If aggradation is sufficient to choke the channels back under the ice, and if the glacier's front is much crevassed, distributary courses diverging from the original, may be formed in adjacent crevasses. The formation of distributaries is a characteristic feature of alluvial fans and of deltas.

Some such combination of conditions evidently existed north of Stillman Valley when the Early Wisconsin ice-sheet was melting. The tract of gravelly hills and ridges tells of heavily laden subglacial streams, the enclosing ice walls are recorded by the steep sides of the ridges, and the position of the ice front is marked by a line connecting the southern termini of the diverging short ridges.

The three groups of ridges are made up largely of distributary branches. Converging, or tributary, branches in the direction followed by the water are rare. There are few gaps in the ridges, which are probably due to a swifter current in the stream across such places so that insufficient debris accumulated to leave a ridge after the ice had disappeared. The orientation of the three groups is such as to suggest that all are but distributary parts of a main stream which lay farther east, and which left no similar ridge because its velocity was too great to allow deposition.

The shaded areas in figure 58 are the gravel deposits, which are seen to control the topography in almost every detail. They fail to make ridges only across the higher tract of till and limestone. Figure 59 shows diagrammatically the probable relationships of the stream courses under the ice.

Such ridges of sand and gravel, associated with glacial drift and doubtless the product of subglacial streams, are known as *eskers*. Separate hills of such material are called *kames,* and are commonly formed at the edge of the ice as steeply sloping alluvial fans deposited against the face of the glacier. The complex character of the Stillman Valley gravel deposit and the prevalence of ridges instead of disconnected hills, suggest the term, an eskerine tract, as being applicable. The abrupt termini of the ridges on the north slope of the pre-Illinoian Stillman Creek valley is good evidence that these distributary streams discharged into ponded water in that valley, water which flooded back against the lower slopes of the glacier itself.

Big Mound Kame.—The most prominent summit in Kings quadrangle is the hill called Big Mound (fig. 60), situated a mile and a quarter northwest of Holcomb and a mile and three quarters southwest of Davis Junction. It lies in the southwest quarter of sec. 27, T. 42 N., R. 1 E. The most striking view of the hill is obtained from the flattish country lying north and east of Holcomb, above which it rises 100 to 150 feet. Its prominence is due as much to its semi-isolation as to its height, though it probably is not more than 20 feet lower than the highest tracts of the quadrangle.

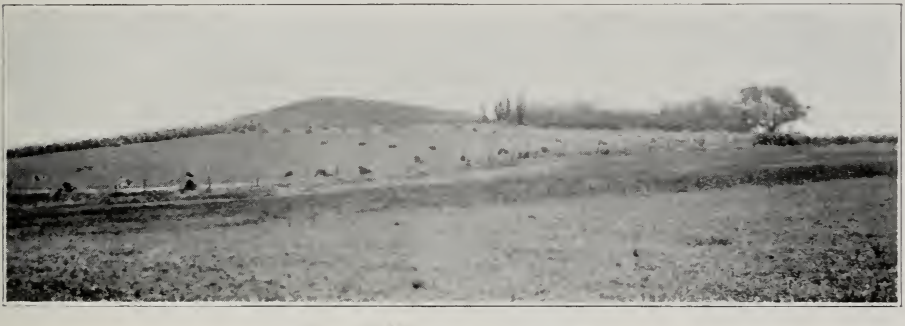

Fig. 60. Big Mound from the southwest.

A large pit on the north slope of Big Mound shows the hill to be composed mostly of gravel, as are the ridges near Stillman Valley. But this gravel is poorly stratified, poorly sorted and much of it is rather angular. Debris of the Galena limestone, which underlies the hill, is very common, but there is also considerable material from the Canadian highlands. The gravel has not been carried far by running water.

The form of Big Mound is that of an asymmetrical cone, the east side being the steeper. This steep slope rises about 60 feet above the plain, and the gravel deposit is probably as deep as the hill is high. Toward the west, the slope is more gradual. Galena limestone is exposed in the cuts of the Great Western Railroad on the southwest, less than a quarter of a mile from, and about 50 feet lower than, the summit of the mound.

Big Mound belongs to that group of fluvio-glacial deposits known as *kames.* Its composition and structure indicate the action of a glacier-born stream, and its topographic situation requires higher tracts, not now existing, from which that stream came. The melting ice doubtless lay to the eastward, and the mound is interpreted as essentially an alluvial fan, deposited against the ice front, probably in a re-entrant angle of the ice front, as is shown diagrammatically in figure 61.

Killbuck Kame Tracts.—Two notable areas of gravelly hills lie in the east-central part of the quadrangle, from two to three miles south and southeast of the village of New Milford. They are both elongated in an east-west direction, and are sub-parallel with each other, one in Winnebago County and one in Ogle County. The Winnebago County tract is really separable into two, each of which is larger than the one in Ogle County.

The gravel in these tracts is aggregated in knolls and knobs of the true kame type. Esker-like ridges, so prominent in the Stillman Valley area, are absent here, and only the linear grouping of the irregular kames suggests a stream course. In the larger tract, north of the Killbuck, the base of the gravel is exposed in a few places, and the deposit is there found to rest on limestone, at least in the eastern portion. The western portion constitutes a spur of hills projecting out into the lower country commonly termed the Kishwaukee Flats, and rests apparently on till. The Killbuck and Kishwaukee here are less than 700 feet above sea level, and wells on the lowland, close to the flanks of the gravelly hills, fail to find rock, though drilled more than 100 feet below the stream level.

The material of this gravel in some exposures is very coarse, even bouldery. The boulders are composed of granite, quartzite and red quartz porphyry, foreign materials which probably were carried on the surface or at least well up in the body of the ice. Had they travelled at the bottom of the glacier, they would have been destroyed by abrasion long before reaching this region, so far distant from the parent ledges.

The slopes of these kames average 10°, but in a few places are 15°, and in one place 17°. This of course takes no account of the erosional slopes caused by Killbuck Creek and its tributary gullies.

These two Killbuck tracts represent marginal accumulations where englacial and subglacial streams suffered considerable decrease in velocity on emerging from their tunnels in or under the ice. Such deposits were made in close association with the fissured and wasting margin of the ice sheet, and the burial of detached blocks of ice must have been common. Subsequent melting of such buried blocks would leave enclosed hollows, a common feature in kame-like areas of the later Wisconsin drift sheet. If such features ever were formed here, or in any of the kame tracts of the quadrangle, they have been destroyed by slope wash and gullying.

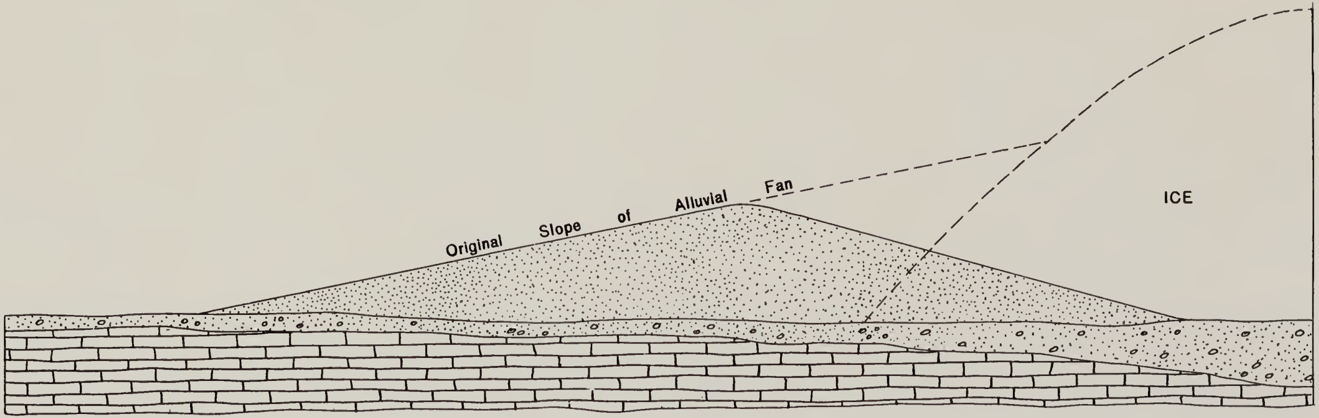

Fig. 61. Diagrammatic section of Big Mound. Probable relationship of the gravel deposit to the margin of the ice sheet at time of formation is shown. Slope wash subsequent to the disappearance of the ice has produced the present eastern face of the hill.

The east-west linear grouping of both tracts apparently marks out the courses of the subglacial streams, but not as the Stillman Valley ridges, which have been interpreted as being deposits in the actual channels in the ice, with all parts of such ridges contemporaneous in origin. In groups like the Killbuck areas, it is much more likely that the various kames were built consecutively at the edge of the ice as it melted back toward the east, the westernmost hills therefore being the older.

Holcomb Kame Tract.—The gravelly hills which lie a half mile to two miles west of Holcomb belong to the same category of kame tracts as do the Killbuck kame tracts. There are three rounded hills in the northern half of section 3, the grouping elongated nearly north-south. The sinuous esker-like ridge of gravel in the northwestern corner of the same section, continues westward for more than a mile, the ridge character and the gravelly nature of the material gradually dying out. The crest of this ridge descends about 50 feet from east to west.

Kings Kame Tract.—This lies one to two miles north of Kings station on both sides of the Chicago, Burlington and Quincy Railroad. It is smaller than either of the Killbuck tracts and not so pronounced topographically. Like the Stillman Valley and Killbuck Valley tracts, its greatest development lies on a western slope of the underlying material, and there is a broad lower tract to the west of it. Such situations appear to have provided the most favorable conditions for deposition by the emerging glacial streams.

A large pit has been excavated for railroad ballast in the Kings kame tract. It is now abandoned and the sides have slumped so badly that the original sections are obscured, but a few small pits still operated for local needs show the structure and composition of the kame tract. The most noteworthy feature in these sections is the presence of orange-stained and cemented gravel below unstained or but slightly stained gravel. The structure of the gravel is the same throughout, as is the composition, except for this difference in staining and partial cementation.

An earlier suggested interpretation of this relationship in the Chicago, Burlington and Quincy Railroad pit north of Kings[10] was that the orange-stained material below was considerably older than the unstained material above. This interpretation assumed the red and orange color to be the result of long-continued surface exposure and oxidation before burial beneath the unstained gravel. It also assumed that the identical features of composition and structure (aside from staining and cementation) were merely a coincidence in materials of widely different ages. The Kings kame thus was taken to record the same history as that deciphered in and about the Illinois Central Railroad cuts, southeast of Rockford.

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[10] Leverett, Frank, The Illinois Glacial Lobe: U. S. Geol. Survey Mon. 38, p. 136, 1899.

Another and simpler interpretation is based on the following points:

(1) The stained and the unstained material are both gravel, of the same sub-angular type of glacial detritus.

(2) There is no soil, peat, muck or other material recording a surface zone between the stained and unstained gravel.

(3) Strata can be traced without interruption from the unstained into the cemented, deeply stained material.

(4) The staining in some places is in pockets or lenses or seams. These patches have unstained, or very slightly stained, material above, below and on the side. They are not, however, fragments of an older gravel in a younger. The stratification is continuous.

The gravel in the Kings kames therefore is adjudged to be one formation, instead of two, and the staining and cementation of the lower portion is ascribed to deposition from ground water subsequent to the deposition of the entire accumulation.

Other Kame Tracts.—There are scattered and smaller gravelly tracts in various parts of the quadrangle which will not be taken up in detail here. One group of kames lies northwest of Davis Junction, nearly in the center of Scott Twp., (T. 42 N., R. 1 E.), Ogle County. Its development is not sufficiently pronounced to show on the topographic map. Like the others noted, it lies on the crest of a western descent to lower land, and its kame-like knobs are best seen from this lower tract.

THE KILLBUCK VALLEY TRAIN

Along the Killbuck valley is a narrow strip of fine gravel, sand and silt deposited by the waters draining into this valley from the Bloomington ice when it was building the high moraine to the east of this quadrangle. The distribution is shown on Plate IV. The deposit is largely intact, for that stream has had insufficient gradient and volume in subsequent time to erode it much.

LATE WISCONSIN DRIFT

As previously noted, there is no Late Wisconsin till in the area, and this epoch is represented only by outwash deposits occurring as valley trains along Rock and Kishwaukee rivers.

THE VALLEY TRAINS

The valley trains of Rock and Kishwaukee rivers consist of a sand and gravel filling, which has been carved by the streams into terraces, now standing a few feet to forty feet above the streams. The larger of these terraced flats lies in the valley of Rock River, north of the junction of the Kishwaukee. Most of the city of Rockford and all of the Camp Grant cantonment are built on it. Erosion by Rock and Kishwaukee rivers has cut this valley floor into four distinct portions, the large tract bearing Rockford and the Camp Grant cantonment, a smaller one west of the river opposite the cantonment, another south of New Milford and between the Kishwaukee and the Killbuck, and a fourth south of the Kishwaukee-Killbuck confluence.

There is a broad tract also in the Kishwaukee valley east of the limits of this quadrangle, which in like manner was originally connected by a long arm westward through the rock gorge to the large tract at the confluence of the three streams.

The gravel deposit may be traced westward and southward through the gorge of Rock River to Byron. In this stretch, the present status of the deposit is like that of the tributary Kishwaukee in its gorge. Only small terrace fragments of the original filling remain. There is a broadening of the valley at Byron, in which deposition occurred, and here there is still a considerable terrace flat. Byron is built on this flat and the large abandoned gravel pit of the Chicago Great Western Railroad a mile north of Byron is excavated in the same terrace.

A comparison of the altitudes of the surface of these terraces is very instructive. At Rockford, the highest part of the surface is about 750 feet above sea level, at Camp Grant railroad station it is 739 feet, and at Byron, 727 feet. This is a descent of 23 feet in about 12 miles, or about two feet to the mile. In the Kishwaukee Valley on the eastern edge of the quadrangle, the terrace of Wisconsin gravel is about 740 feet above sea level The distance from here to Byron by the valley is about 15 miles, and the descent is 13 feet, approximately a foot to the mile.

These are low gradients, but they correspond closely with present gradients of these streams. The 700-foot contour crosses the river at the dam in the city of Rockford and the river surface at Byron on July 11, 1916, was 670.6 feet above sea level. The distance, following the curves of the river between these two points is about 17 miles and the gradient therefore less than two feet to the mile. During ordinary stages, Rock River carries only mud in suspension, and rolls only sand along the bottom in the shallower stretches. But the stream in flood shifts the position and outline of its gravel bars and thus gives evidence of its ability, with sufficient volume, to transport gravelly material on this gradient.

There is a clear inference from this description of the Wisconsin gravel terraces, and of the present gradient and work of Rock River. It is that these terraces, now interrupted by the present stream channels and flood plains, were once continuous river flats, deposited by streams larger than those of today, and amply supplied with debris. When these terraces are traced up the valley of Rock and Kishwaukee rivers, beyond the limits of Kings quadrangle, they are found to head at, or near, the edge of the Late Wisconsin drift sheet of the State of Wisconsin.

The melting of that ice sheet was relatively rapid and supplied great quantities of water. The water, escaping beyond the edge of the ice, was carried away by existing valleys open to its entrance. The Kishwaukee and Rock are two such valleys, the Wisconsin ice having crowded over into the headwaters of each. The large volume of water and large supply of debris from the melting ice gave rise to swollen, turbid streams in these valleys. These streams carried and deposited the gravel which today lies in broad flats along the valleys. Such deposits by glacier-born streams are termed *valley trains.*

The greatest original expanse of the Wisconsin valley train on Kings quadrangle was at the confluence of the three valleys, south of Camp Grant. Here the gravel was spread out to encircle two hills of Early Wisconsin till (see Pl. IV), one west of the South Bend School and one between the Kishwaukee School and Camp Grant. These hills were separated by small valleys somewhat lower than the surface of the filling and were in the direct path of the escaping water.

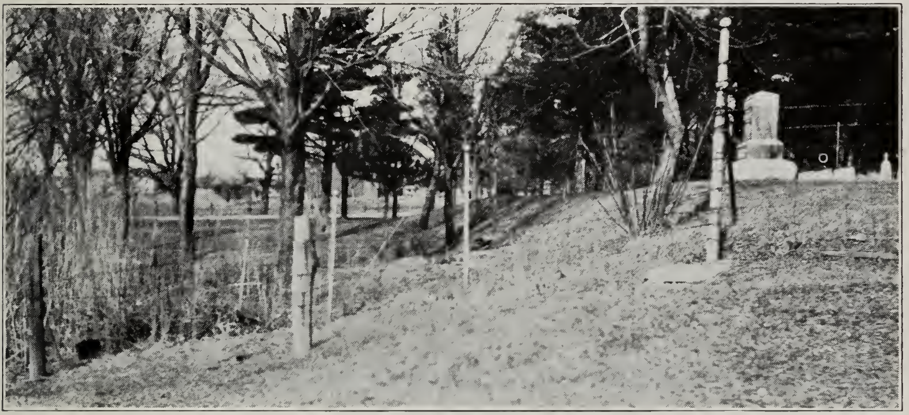

Fig. 62. Terrace in Pleistocene lake bed at Stillman Valley.

Certain valleys of Kings quadrangle, tributary to Rock River, did not receive this outwash gravel from the melting ice. They do contain fillings, however, of the same general appearance and topography with their surface altitudes commonly the same as that of the adjacent valley train, but the deposits are composed of much finer material, chiefly sand, silt and clay. In the valley of Stillman Creek, they are terraced in the same fashion as in the valleys containing outwash deposits.

Their explanation is simple and obvious. Outwash gravel in Rock River valley blocked the lower portions of these tributaries. In some, the accumulation of stream material in the tributary valley may have kept pace with the building of the valley train, but probably in most cases, a ponding resulted which in two instances attained the dignity of lakes. One of these lakes was in the valley of Stillman Creek (fig. 62) and its tributary, Black Walnut Creek. The other was in the southern portion of the Kishwaukee Flats. These two water bodies nearly joined across the low divide northeast of Stillman Valley, the altitude of which does not exceed 760 feet above sea level.

RECENT DEPOSITS

The term "Recent" is here used to include deposits made since the deposition of the Wisconsin valley trains. Such deposits are few and relatively insignificant.

LOESS-LIKE LOAM

Some of the material termed loess-like loam overlies the Wisconsin gravel and therefore is younger. There is a good exposure of such in the southern part of Rockford, half a mile north of the northern boundary of this quadrangle. Considerable excavations of the valley train gravel have been made and sections of the overlying material exposed. It has a maximum thickness of eight feet and is definitely stratified. The stratification, shown in figure 63, is peculiarly irregular and the darker wavy bands contain more clayey material than the lighter colored layers.

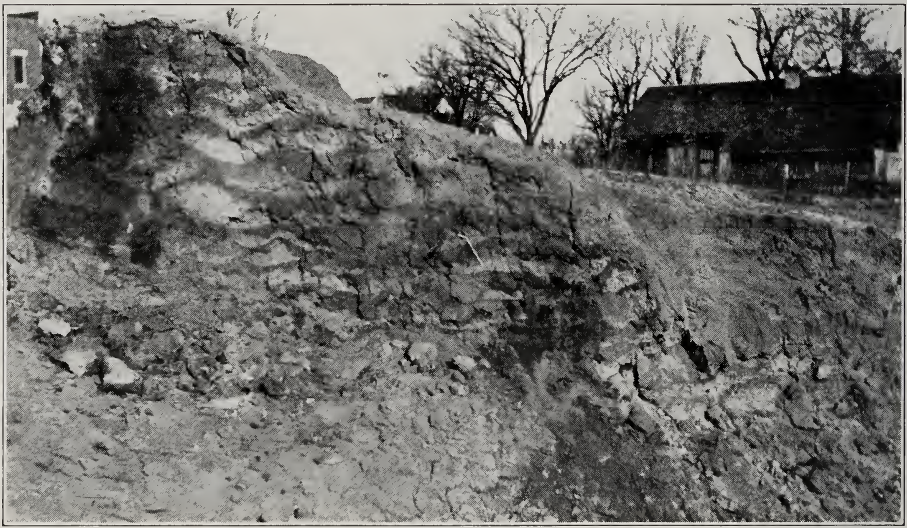

Fig. 63. Loess-like deposit in southern part of Rockford.

The surface of the valley train elsewhere bears a cover of loam, though not to the depth noted above. This constituted the mud and dust of Camp Grant, which was so notable on unpaved paths and parade grounds. The cloud of dust whipped up on windy days from the cantonment's trodden areas was visible on occasions as a yellowish smudge in the sky from Big Mound, nine miles distant. The destruction of the cover of vegetation and the constant breaking up of the dried and caked mud by trampling of men and horses were the artificial factors in this excessive transportation of dust.

DUNES

A few low mounds of sand lie at various places along Rock River valley. Some of them are nearly barren of vegetation. Most of them rest on the Wisconsin gravel, though some of them are above it and some on the Illinoian till. They are clearly the product of the wind, the sand having been blown up from the river flats and lodged in favorable situations. None of them is more than ten feet high. One tract of such dunes lies along and south of the Kishwaukee Road in the southwestern part of the Camp Grant cantonment. Two other tracts lie on the south side of Rock River between Camp Grant and Byron.

ALLUVIUM

The larger streams of the quadrangle have trenched a few feet to a few tens of feet into the Wisconsin gravel or its associated alluvial and lacustrine deposits. The floors of these trenches, or inner valleys, are covered with recently deposited mud, sand and gravel, the finer constituents predominating. Such material is left during flood time, when the streams inundate the low land. Valley floors subjected to this condition are *flood plains.*

Killbuck Creek has cut so little into the Wisconsin outwash that the valley train for much of the stream length constitutes the flood-plain. The upper portions of Stillman Creek and Black Walnut Creek have flood plains eroded in Illinoian till. Elsewhere, these tracts of present-day deposition generally are bounded by terraces of the Wisconsin outwash.

The flood plain material has been augmented considerably by swamp accumulations on the low wet lands. One of the largest of these swamps lies east of the South Bend School in the valley of Killbuck Creek. In part, it lies on a lower terrace of the Wisconsin outwash, above the flood level, and therefore owes its existence to the seepage of ground water. The higher portion is crossed by the Chicago, Burlington and Quincy Railway. This swamp, and another large one two or three miles farther up the Killbuck, belong to the hummocky type of sedge and grass swamps.

CHAPTER IV—GEOLOGICAL HISTORY OF THE REGION

The book of geological history is the crust of the earth, and the pages of that book are the rock formations. The characters inscribed on those pages are the features of these formations which have been considered in the foregoing chapters, as: composition, structure, fossils, distribution, contacts, altitudes, and other similar data. Various agents have had a part in recording this history,—especially the atmosphere, ocean, running water, and ice sheets, but some of these agents have erased and written over previous records.

Cambrian History

In the deepest drillings within the limits of the State of Illinois is found no earlier formation than that known under Kings quadrangle. The history, from Illinois records, begins with the presence of a shallow, agitated sea, reaching in as a widespread inundation on the continent from the surrounding deep oceans. In this epicontinental sea the sand removed by erosion from the land of that time was deposited on the submerged tracts of the continent. The source of the sand appears to have been to the north. Changes in depth, changes in shore lines, and changes in character of debris made the sediments of this sea (the Croixan or Potsdam sandstone) a variable formation. Shaly members record deeper or more quiet water, while the dominant sandy material clearly indicates vigorous circulation produced in relatively shallow water by waves, currents born of wave-action, and tidal ebb and flow.

The Potsdam sandstone is at least 1500 feet thick under Kings quadrangle, a thickness far greater than the depth to which agitation extends in standing water. The Cambrian sea, therefore, must have been shallow to begin with, and the region must have subsided during accumulation of the Potsdam formation, but not faster than deposition occurred. This inference is based on the shallow-water and near-shore character of the formation throughout its great thickness.

Deposition of the Potsdam (Croixan) formation is generally considered as the culminating event of the Cambrian period of earth history. Deposits of earlier epochs of this period are unknown in the central part of the continent though they are present nearer the margins. It is inferred from this that the Cambrian sea gradually encroached on the land, its shallow waters creeping inland until it finally reached and flooded what is now the drainage area of the upper Mississippi. The Potsdam sandstone was deposited during this maximum flooding.

Table 7.—*Geologic time divisions showing periods for all geologic time, and epochs for those periods recorded in north central Illinois*

Eras	Periods	Epochs
Cenozoic	Recent (Post-glacial)	
	Pleistocene (Quaternary)	Wisconsin glacial Peorian interglacial Iowan glacial Sangamon interglacial Illinoian glacial Yarmouth interglacial Kansan glacial Aftonian interglacial Nebraskan glacial
	Pliocene	
	Miocene	
	Eocene	
Mesozoic	Cretaceous	
	Comanchean	
	Jurassic	
	Triassic	
Paleozoic	Permian	
	Pennsylvanian	
	Mississippian	
	Devonian	
	Silurian	
	Ordovician	Cincinnatian (Maquoketa) Galena Platteville (Trenton) St. Peter Prairie du Chien (Lower Magnesian)
	Cambrian	Potsdam (Croixan)
Proterozoic	Keweenawan	
	Animikean (Upper Huronian)	
	Middle Huronian	
	Lower Huronian	
Archeozoic	Archean	

It is interesting to note that in districts where the Potsdam is exposed, it yields fossils of marine animals. These fossils belong to several great classes of the animal kingdom. Trilobites are common. They belong to the class *Crustacea,* of which the common freshwater crayfish or "crab," and the salt water lobster and true crab are living representatives. Trilobites have been extinct for many geological periods.

Pelecypods are present. Their modern representatives are the fresh water and salt water clams. Gastropods or snails also are present. Both the bivalved pelecypods and univalved gastropods belong to the class *Mollusca* of which modern freshwater representatives are familiar.

The brachiopods constitute another common type of fossil found in the Potsdam sandstone. They are bivalved, like the pelecypods, but their internal anatomy is notably different, and they differ in the symmetry of their shells.

Other less widely known types also lived in the Cambrian seas, but there were no vertebrate animals. This means that no fish swam in that ancient sea, so far as is known at the present time.

As formations older than those of the Cambrian yield few traces of organisms, the Potsdam sandstone contains one of the earliest adequate records of life on the globe. It is impossible to say how long ago, in terms of years, this Cambrian sea existed, but the estimates of various careful students range from tens of millions to hundreds of millions of years. The later estimates, based on a broader knowledge, are the larger figures.

Ordovician History

The transitional events in this region from the Cambrian to the Ordovician period apparently were not noteworthy though there is evidence elsewhere of a somewhat protracted interval of emergence between the Cambrian and Ordovician periods. The conditions of early Ordovician time are recorded in the Prairie du Chien limestone. They involved a cessation of the great contributions of sand to the interior sea, and the deposition, instead, of calcareous mud. Probably the land areas during Prairie du Chien time were farther from this region and perhaps they were lower, so that streams acted less vigorously and carried off less debris. The rate of sedimentation was doubtless much slower during the Prairie du Chien epoch than during the Potsdam epoch. The debris from the shells and other hard parts of marine organisms accumulates slowly, some estimates placing it at about a foot a century. Approximately 100 feet of Prairie du Chien limestone therefore probably records a much longer time than an equivalent thickness of Potsdam sandstone. It is unsafe, however, to generalize on the relative duration of the two epochs. There are too many variable factors which control the rate at which different kinds of sediments are laid down, and the conditions during these epochs are but imperfectly known.

One might think that since the Prairie du Chien is largely calcareous material, marine life must have been far more abundant during this epoch than during the Potsdam. Such a conclusion however does not necessarily follow. It is not so much the abundance of lime-secreting organisms, as the paucity of earthy sediment, which insured dominance of calcareous material in a formation.

Limestones record clear and quiet seas. Most of the fossils contained in limestone formations are relatively shallow-water forms and most of them lived on the bottom. Much disturbance by tidal and shore currents would have caused muddy water and thus forbidden their existence. As nearness to the shore usually guarantees disturbing currents, it is believed that the interior sea during the Prairie du Chien epoch was wide and clear.

The transition from the shallow disturbed waters of the Potsdam epoch to the more quiet and clear conditions of the Prairie du Chien epoch probably was due to a re-occurrence of subsidence, such as invited the sea into the region originally. The shores thus were moved farther from this area, the lands were decreased in area, and the epicontinental sea encroached more and more widely.

But this sequence of events was interrupted at the close of the Prairie du Chien epoch. As pointed out on page 223, there is good evidence in the deeper well records of an unconformity between the Prairie du Chien and the overlying St. Peter formation. The unconformity is actually observable in many places in southern Wisconsin where the contact of the two formations is exposed at the surface. The unconformity records an uplift of the region, a drawing off of the epicontinental sea, and an epoch of erosion of the recently deposited material. In some places in Wisconsin, the Prairie du Chien was entirely removed, and the streams of that epoch cut into the underlying Potsdam formation.

The St. Peter formation, which overlies the Prairie du Chien formation, is composed of remarkably clean, well-sorted sand. The entire absence of fossils and of variations in texture throughout most of its extent have suggested that the St. Peter sandstone was deposited under special conditions, unlike those which generally control the accumulation of sandy materials. Deposition by wind on the land is the explanation which has been suggested. According to this conception, the sand was blown here from regions probably farther north. Perhaps it migrated, as dunes are known to travel. If this formation is an eolian deposit, the climate of the region during that epoch must have been arid, and the landscape that of a sandy desert. This conception does not require a re-submergence to account for the origin of the St. Peter formation.

According to another conception of its origin, the eroded Prairie du Chien formation was submerged beneath a re-advancing sea, and the sand was deposited in that sea as the Potsdam sandstone was during the preceding period. The absence of fossils may mean in this case that the St. Peter sea was not populated with shell-secreting forms, or more likely, that shells once embedded in it have been dissolved out since. The porous nature of the sandstone, facilitating the circulation of water through it, makes this seem very plausible. The formation is much too uniform in thickness over wide areas to make the eolian origin of the whole seem probable. It is quite likely that the St. Peter sandstone is partly eolian and partly marine.

Whether or not subsidence occurred immediately after the erosion of the Prairie du Chien limestone, it surely had occurred by the time events had ushered in the Platteville (Trenton) epoch. The Galena formation is a true marine deposit and records, like the Prairie du Chien, the existence of a broad sheet of clear and relatively shallow ocean water extending into the heart of the continent. With this encroaching sea came the organisms of the sea, and in the protracted inland waters, they flourished for long ages, their skeletal parts and shells collecting slowly on the bottom until both the Platteville and Galena limestones were deposited.

As already indicated, these limestones are very much alike in lithological characteristics and require the aid of fossils for their differentiation. From this we conclude that no physical changes of consequence occurred in the marine submergence of the region from the beginning of the Platteville to the close of the Galena epoch. There were changes in form of life, however, the most noteworthy of which was the complete disappearance of the interesting Receptaculites at the close of the Galena epoch.

Reference has been made repeatedly to the shallowness of these epicontinental seas. Proof that the water during at least one time in the Galena epoch was so shallow that the waves swept the bottom is to be found in the Carrico quarry in the northwestern part of Rockford. A broad shelf of the horizontally bedded limestone has been left on the east side of the quarry. The surface of this shelf is the surface of a stratum of limestone. This surface is ripple-marked, as shown in figure 64. The distances between the ripple crests average two feet. Several thousand square feet are covered with them.

Ripple marks are familiar. Small ones, a few inches from crest to crest, are common on sandy bottoms affected by waves or currents. The larger ripples are formed at greater depths. The ripple-marked surface in the Carrico quarry was at one time a chalky mud bottom, over which rolled the billows of a widespread interior sea, so shallow that the larger waves dragged bottom.

The combination of ripple marks in limestone containing marine fossils thus records a number of interesting things. It proves (1), that the region was submerged beneath the sea; (2), that many organisms, now extinct, existed in this water; (3), that the water was not deep; (4), that winds swept the surface of this sea and produced large waves; and (5), that this particular wind, millions of years ago, blew from the southwest, the direction of the prevailing winds of the region today. The lesson to be drawn from this is that the processes and agencies of the present have operated on the earth as far back in the distant past as we can read the record. The earth has not had a catastrophic, short-term making. It has been evolving for uncounted and uncountable milleniums and is yet in the making.

The Platteville formation is now considered as the equivalent of the lower portion of the Trenton of New York State. The sea in which it was deposited, commonly is called the "Trenton submergence" or "mid-Ordovician transgression." At its maximum extent this sea probably reached from the Gulf of Mexico to the Arctic Ocean, had connections with the Atlantic and Pacific oceans and covered nearly half the continent. Though geological history has seen many emergences and submergences of North America since the Trenton (Platteville) epoch, there probably never has been one more extensive than this. The modern homologue of these ancient epicontinental seas is to be found in Hudson Bay, an immense sheet of shallow marine water lying on the continent, its maximum depth being only 650 feet. Its area is small, however, compared with some former epicontinental seas.

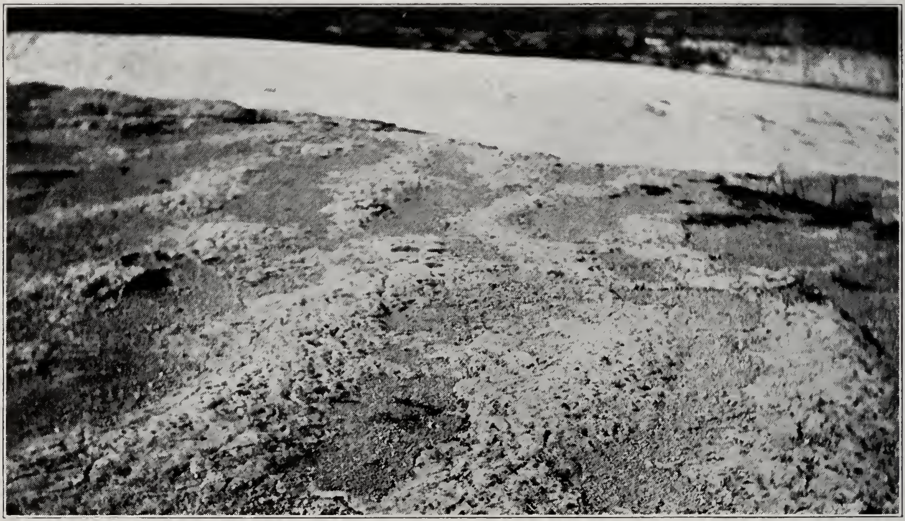

Fig. 64. Ripple marks in Galena limestone.

Post-Ordovician Pre-Pleistocene History

The Galena limestone is the last record of marine submergence of the region within the limits of Kings quadrangle. Whatever younger formations may have been laid down in later seas have been removed completely by erosion. We know, however, that there are many younger marine formations in the Upper Mississippi Valley. The Ordovician formations dip south at a gentle grade and pass beneath later deposits. The older of these overlying formations probably once covered this quadrangle, but many of the younger ones never did. In other words, the region of Kings quadrangle became land, and suffered erosion as lands do now. Instead of receiving deposits, it yielded waste to the seas of that time, thus helping to make other formations. This is exactly what is happening today, and it is an epitome of what has been happening throughout much of the region's post-Galena history. It is clear that the sea level has been a critical level for the region studied. When the region was below this level, aggradation occurred here, and when it stood above, degradation dominated.

Erosion, therefore, controlled the situation for long ages in northern Illinois after the early Paleozoic formations were deposited. But other events had occurred before. (1) The calcareous muds were consolidated in their own cementing material and the sandstones were cemented by percolating solutions. (2) Along certain planes of stratification in the limestone occurred a noteworthy growth of nodular concretions of chert or impure flint. (3) The magnesian character of the limestones may be largely, perhaps wholly, a matter of subsequent changes in the original calcareous sediments. (4) Vertical cracks or joints were produced, especially in the limestones, and (5) some warping occurred in the region. These changes will be considered in more detail in the order mentioned above.

CEMENTATION AND CONSOLIDATION OF THE SEDIMENTS

Sediments deposited in standing water are originally incoherent and unconsolidated. They may become indurated rock in several ways.

COMPRESSION

Compression caused by the weight of overlying deposits will squeeze out the water and if the material is fine-grained will compact the mass into solid rock. This may have been a minor item in consolidation of the limestones of Kings quadrangle, and would at least begin while the material still lay beneath the waters in which it was deposited.

CEMENTATION

Cementation is caused by precipitation of calcium carbonate (the chief constituent of limestone), silica (the principal constituent of sandstone), and iron oxide. Lime muds have an abundance of calcium carbonate in the water which saturates it and cementation by this material is to be expected. Silica is likely to be abundant in the interstitial water of sands, and is therefore the common cementing material in sandstones, though iron oxide is present to a minor degree.

DEVELOPMENT OF CHERT CONCRETIONS

Silica in disseminated form in calcareous muds is commonly segregated during cementation into nodules or concretions. The habit of these nodules to develop along certain planes of stratification is well shown in some parts of the Galena limestone. In some cases, the silica is sufficiently abundant to make thin strata of coalesced nodules, as shown in figure 48.

DOLOMITIZATION

Magnesian lime muds may accumulate if the contributing organisms build shells containing magnesium carbonate. Most dolomites and dolomitic limestones, however, probably originated by replacement of a portion of the lime carbonate by magnesium carbonate through the action of sea water, soon after the calcareous sediments were laid down. Such a change involves a decrease in volume of the whole, and if the change takes place after induration, that would account for the many small cavities common in such formations. The Galena limestone illustrates this carious condition admirably. If such replacement took place in the Platteville and Galena limestones, it may help to account for the paucity of good fossils in them.

JOINTING

One of the structural features of both exposed limestone formations in Kings quadrangle is the occurrence of vertical planes of fracture which, in quarries and bluffs, have nearly straight vertical walls. These are *joint planes.* They belong to two systems which cross each other nearly at right angles. One system is oriented 70° to 75° west of north, and one 15° to 20° east of north. They are ascribed to slight warpings caused by crustal movements during and subsequent to the emergence of these formations from the sea.

WARPING

The strata of Kings quadrangle are not perfectly level, though their departure from horizontality is in general slight, and varies in amount and direction from place to place. Some of this may be due to uneven surfaces on which the formations were deposited, but more probably there have been warpings during the different uplifts and depressions the region has suffered since the Ordovician period.

The most noteworthy local deformation in the quadrangle is well exhibited along the road 2½ miles north of Byron, on the hill slope north of the buildings of the McCormick Dairy Farm. The exposure is in a small roadside quarry and the strata here dip about 10° to the north. Such a dip as this, if very extensive, would produce notable differences in altitude of the formations north and south of it. Since no great differences are reported from well records, it is obvious that this warping is local. It may, however, be related to a discrepancy in altitudes of the top of the St. Peter in the vicinity. Mr. Paul Millis of Byron made the statement that the St. Peter sandstone outcrops in the bed of Rock River a mile south of the tilted beds, though it is never exposed even at low water. The altitude of these ledges of sandstone can not be higher than 675 feet above sea level. Half a mile north of these tilted strata, the McCormick well reached the top of the St. Peter at 530 feet above sea level. The differences in altitude between the two is 145 feet, and the north-south distance is a mile and a half. This requires a dip of about 1°. A 10° dip involves a rise or fall of 17.63 feet for every 100 feet of horizontal distance. Obviously the dip shown in the exposure can not extend very far.

Diastrophic movements in some cases are very local. Actual folding of the rocks results where they are compressional in a horizontal direction and of sufficient strength. The upfolds are known as *anticlines,* the downfolds are termed *synclines.* They are essentially wrinkles in the rock.

The great structural feature of the strata of Illinois is a long anticlinal fold which extends from Stephenson County in a southeast by south direction to Lawrence County, three-fourths the length of the State. This fold is well exposed near LaSalle where Illinois River has cut across it, and is known therefore as the LaSalle anticline. It is but slightly developed in Ogle County southwest of Oregon, where it is nothing more than a broad low upwarp in the strata. Its uplift, plus the lower level of Rock River downstream, has exposed the Prairie du Chien limestone between Oregon and Grand Detour. In Kings quadrangle the influence of the LaSalle anticline may be seen in the altitudes of the surface of the St. Peter sandstone in different places. In Rocky Hollow near the southwestern corner of the quadrangle the top of the St. Peter is 810 feet above sea level. A mile farther north, it is 730 feet above sea level, a descent of 80 feet or a dip of less than 1°. These places are on the eastern edge of the anticline.

A mile south of Byron, the top of the St. Peter sandstone is 630 feet above sea level. This is six miles north of the last cited locality, and only 100 feet lower. In the McCormick well three miles north of Byron, the St. Peter sandstone is 530 feet above sea level, a descent of 100 feet in four miles. This north-south line has been determined by available well records, and is not necessarily the direction of maximum descent. Few wells in the quadrangle go to the St. Peter sandstone.

Beneath the city of Rockford, if the well records may be relied on, the upper surface of this formation (where overlain by limestone) varies at least 88 feet in altitude. The highest surface of the St. Peter reported here is 610 feet above sea level in the well of the Love Manufacturing Company, and the lowest is 530 feet in the well of the Burson Knitting Company. These wells are not more than three blocks apart, and the difference in altitude of the top of the St. Peter can hardly be due to dip of beds. Repeating the caution "if the well records may be relied upon," the conclusion may be reached that either there exists here an erosional surface on the St. Peter and below the Platteville, or that the irregularities possibly were determined by dunes on the surface of the St. Peter sandstone.

SEDIMENTATION AND EROSION

The gap in the stratigraphic record between the deposition of the Galena limestone formation and that of the pre-Illinoian gravel formation is far longer than the total time recorded by the strata known to underlie the quadrangle. It includes the five periods of the Paleozoic era which follow the Ordovician, all of the periods of the Mesozoic era, and most of the Cenozoic era. Not all of this great lapse of time was passed with the region above sea level. It is certain that one younger Ordovician formation (the Maquoketa or Cincinnatian shale) was deposited conformably on the Galena limestone during that same submergence. It is now found beneath the drift just east of Rochelle, Fairdale, and Belvidere and fails to reach the southeast corner of the quadrangle by a very few miles only. It is almost as certain that the Niagaran limestone, deposited during the following Silurian period, once covered the region, for it now outcrops both to the east and west. It is possible that Devonian and Mississippian seas, following the Silurian submergence, also transgressed this region, though the evidence for this is indefinite. But the Pennsylvanian and later seas did not extend this far inland, though they reached as far north as LaSalle and Bureau counties, the northern limit of the coal fields.

All of the Mesozoic era and most of the Cenozoic witnessed erosion and degradation in this region. It was during this long time that the later Paleozoic formations were worn away, and the Ordovician rocks uncovered and partially removed. The time interval was ample for the removal of all Paleozoic formations if the region had been sufficiently high above the sea. The survival of some indicates that they lay too low for the streams to attack. Running water is most effective when flowing on steep gradients, and since it inevitably wears down the surface, the water lowers the gradients which give it effectiveness, and gradually reduces the amount of erosion it performs. There is an interesting series of changes in the work done by streams during this general lowering of gradients, a series known as the "life history" of stream valleys, or as the *cycle of erosion.*

THE CYCLE OF EROSION

Let us consider the drainage of a tract newly uplifted from the epicontinental sea. The new land slopes down toward the sea. It is not perfectly plane, but has some sags and some swells. Run-off flows in the most direct down-slope courses available. A sag will invite the run-off of adjacent slopes, and this results in a concentration of running water in these lower places. Shortly, the erosive action from this concentration will produce gullying, the incipient form of a stream valley (fig. 65). Gullying steepens the gradient, quickens the flow of water concentrating in the gully, particularly at the head, and the result is that as the gully is deepened, it also is lengthened. Such gullies develop in a few years, or even after a few storms, in slopes of unprotected and unconsolidated material. Plowed hillsides are most frequently affected.

As the gully is deepened and lengthened, it collects more run-off and by collecting more run-off increases its ability to deepen and lengthen. The rate of growth in depth and length increases for a time. The main gully is soon a ravine. Its sides are steep; its stream is swift; and its width at the bottom is not much more than that of the stream which occupies it. A few gullies appear in the sides of the ravine and reach out as tributaries, growing in the same fashion as the ravine grew.

The valley is young, and as yet there are few of them on this recently emerged land. Wide areas between the young valleys have no stream courses but may have swamps and lakes. Such areas are broad, flat-topped divides, and they dominate the landscape. The whole topographic expression is one of youth.

The deepening of a stream valley decreases the gradient to the sea and consequently decreases the velocity of the stream. With diminished power, the stream lowers its valley floor less and less rapidly. Obviously, it must eventually cease to cut more deeply, for its depth-limit will have been reached. This will be the lowest slope on which the stream can flow and carry its load of waste. The depth-limit will be at sea level only at the mouth, and it will be highest above sea level at the head of the stream.

While the stream is deepening and lengthening its valley and while its tributaries are sending out their tributaries in turn, decreased velocity in the main valley is allowing the current to be deflected easily to one side or the other. Such deflection permits the stream to undercut its valley walls here and there and thus to produce a wider valley bottom. Shifting of the location of such deflections will subject all parts of the bounding slopes to the undercutting and will produce a flat-bottomed valley. By the time that widening is well begun along the main stream, the tributaries have so increased in number and length that the flat, broad divides of youth have largely vanished and with them, the swamps and lakes of the uplands. The region is mostly in valley slopes and is well-drained. Deepening along the main streams has approached its limit; lengthening of all courses has about ceased; there is no room for more valleys or ravines; and development of the drainage system is complete. The upland flats are about gone, the lowland flats are just begun. Most surfaces are slopes. The strong, rugged lines of topographic expression are those of maturity.

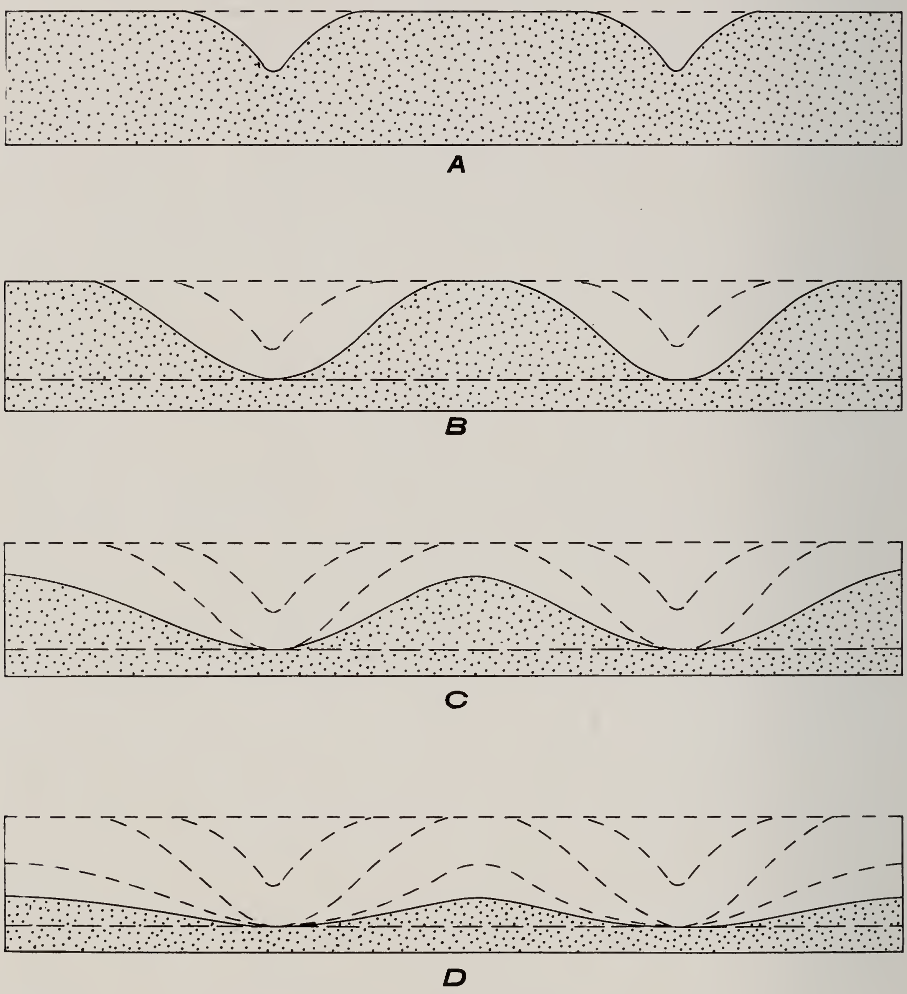

Fig. 65. Cross sections of valleys at different stages in the cycle of erosion.

A. Youth. The valleys are steep sided and the divides are broad and flat.

B. Maturity. The valleys have about reached the depth limit, indicated by the dotted line and have so widened that the divides are narrowed to ridges. Widening at the bottom of the valleys has begun. The region is mostly in slopes. The original upland plain is mostly gone.

C. Early old age. The valleys have wide flood-plains and gentle slopes. The original plain is wholly gone, divides are being lowered and the lowland plain is increasing.

D. Old age characterized by the peneplain. The valleys are very wide, the divides are about as low as slope wash will bring them. A general lowland plain has been produced.

The main stream will deepen its valley somewhat more, but the decreasing gradient will cause it to swing in ever-increasing loops and meanders and widening will now exceed deepening. Lowering on the divides and the valley slopes will now go on more rapidly than in valley bottoms. Eventually the valley floor will be down to the lowest level (the level of *base level*) to which the stream, under existing conditions can bring it, and the larger tributaries will later find this same depth-limit.

The steepness of slopes will decrease, some smaller valleys will become obliterated by widening of adjacent larger ones and the total number of valleys therefore will become less and the region will enter into topographic old age. At this stage, all but the smallest tributary valleys have flood plains, the widest along the largest streams; river currents are sluggish; and divides low and all slopes gentle. The original upland plain is entirely gone but the new lowland plain is well begun and the region's topography is passing into another monotonously placid expression, that of senility. A cycle has been nearly run, the *cycle of erosion.* When this is essentially complete, divides will be down as low as rain-wash and rivulets can bring them. A base level for the region will have been attained. This base-leveled surface is known as a *peneplain.* It is the end product of the cycle of erosion.

An attempt has been made to interpret the bed rock topography of the Kings quadrangle which was developed before the Illinoian ice deposited its till sheet in terms of the stages recognized in the cycle of erosion.

PRE-ILLINOIAN TOPOGRAPHY

The higher tracts of bed rock topography in the quadrangle lie in the northwestern, southwestern, and southern portions. The rock here is but thinly covered with till and has a gently undulating surface between 850 and 900 feet above sea level. A thinly drift-covered, broad summit tract at 840 to 880 feet occupies the northeastern part of the quadrangle. The lower tracts which separate these uplands are the result of stream erosion and it is highly probable that at one time this upland surface extended completely across the region without interruption by valleys.

This upland surface is not determined by the original surface of the underlying, indurated sedimentary formations for the Maquoketa or Cincinnatian shale and the Niagaran limestone with aggregate thickness of about 600 feet, which probably once covered the area, have been removed completely by erosion. Nor is it determined by the bedding of a resistant formation, for the base of the Platteville limestone is but 100 feet below this surface in the southwestern part of the quadrangle and is 250 to 350 feet below in the northeastern corner. Indeed, the dip of the contact of limestone on St. Peter sandstone is downward toward the east, northeast, and

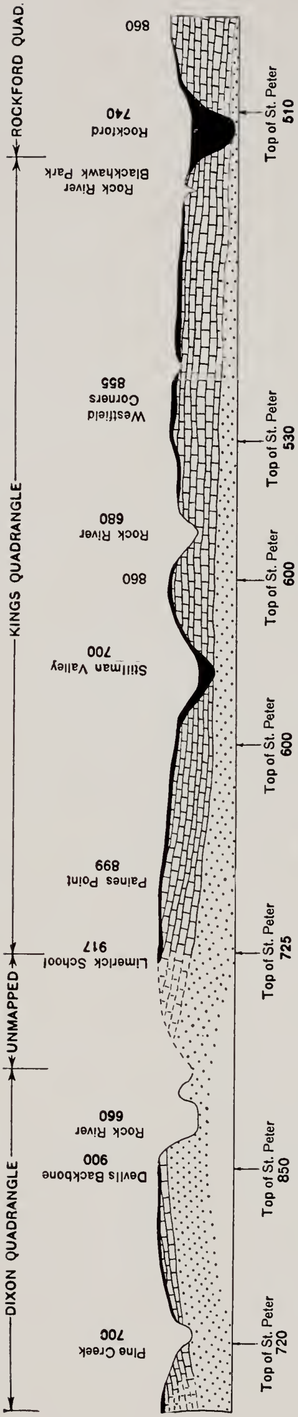

Fig. 66. Diagrammatic section on Dixon, Kings and Rockford quadrangles, showing divergence between summit levels and structure. All elevations refer to sea level. The vertical scale is 25 times the horizontal.

north in the quadrangle, while the scattered remnants of the upland are all at about the same altitude.

This discordance of structural dip with the broad summit tracts is even more marked in the Dixon quadrangle, diagonally southwest of Kings quadrangle. The LaSalle anticlinal fold is crossed by Rock River on this quadrangle. The contact of limestone on St. Peter is 850 feet above sea level on the crest, at the Devils Backbone south of Oregon, but descends both east and west from the axis.[1] Yet the broad flattish hill tops have no corresponding variations in altitude. They preserve much the same height across the anticline which they have in Kings quadrangle (fig. 66).

It seems clear, therefore, that the fairly even summit level of the rock hills of the region is not explainable in terms of original surface of the sedimentary formations or of structure. There is but one other explanation adequate in this case.

It is that these accordant summits are the remnants of an ancient plane surface, worn down to essential flatness (a peneplain) by the erosion of running water during the long time after final withdrawal of the Paleozoic sea, and before the present valleys were formed. This conception implies that the land stood at a level lower than at present, for a time sufficient for all the sequential changes which are involved in a cycle of erosion. It also requires uplift of the region after this cycle of erosion had been completed, the streams being thereby rejuvenated and a new cycle inaugurated. The present topography is largely the product of this second cycle.

A similar old peneplain, now represented by summit remnants only, has been identified with reservations in the Lancaster-Mineral Point quadrangles of southwestern Wisconsin.[2] A similar interpretation has been made for summit levels in the Galena and Elizabeth quadrangles of northwestern Illinois.[3] In both areas, the flattish summits are underlain by Niagaran limestone. The northern portions are the higher, the gradient of the old surface now descending southward about 11 feet to the mile. The structure in both cases is essentially parallel to the surface. A rival hypothesis, that of structural control, has been advocated for these accordant upland levels,[4] but this alternative explanation has much less support than the original. Possibly the question can not be settled from the evidence obtainable from southwestern Wisconsin and northwestern Illinois. In north-central Illinois, however, there is clear and undisputed evidence that the upland surface (neglecting the drift) is not parallel with the structure, but distinctly truncates the underlying strata. Until the region between Kings quadrangle and the Galena and Elizabeth quadrangles is mapped topographically, it will be impossible to say whether or not the upland tracts in each are portions of the same original surface, though this seems probable.

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[1] Knappen, R. S., Personal communication.

[2] Grant, U. S., and Burchard, E. F., Lancaster-Mineral Point Folio (No. 145), U. S. Geol. Survey Geol. Atlas, p. 2, 1907.

[3] Trowbridge, A. C., and Shaw, E. W., Galena and Elizabeth quadrangles: Ill. State Geol. Survey Bull. 26, p. 136, 1916.

[4] Martin, Lawrence, Physical Geography of Wisconsin: Wis. Geol. and Nat. Hist. Survey Bull. 36, pp. 55-70, 1916.

The summits of the rock hills of the quadrangle are about 900 feet above sea level. The surface of the bed rock beneath Rockford and along a linear tract southward toward Lindenwood has an altitude of 450 feet above sea level, even less in places. There is, therefore, a total relief of 450 feet or more in the topography of the rock beneath the drift. This low tract is a great valley in the rock, and is the pre-glacial valley of Rock River. Though deeply filled with glacial material, it is yet the dominant lowland of the area. Another similar valley in the surface of the rock, largely filled with drift, extends eastward from Byron through Stillman Valley, and joins the major valley two or three miles south of New Milford (fig. 69, page 282). Its course is also marked by broad lowlands.

These partially filled valleys clearly antedate the Illinoian drift. The larger one has been traced from the southern part of Wisconsin southward across Kings quadrangle, and, according to Leverett,[5] extended southwestward to join the Illinois Valley below Hennepin. The smaller valley referred to above is the lower portion of a pre-glacial valley which led eastward to the main valley in the eastern part of the quadrangle. It may be looked upon as the valley of the pre-Illinoian Leaf River. The broad Kishwaukee Valley, shown on the Belvidere and Kirkland quadrangles, east and northeast of Kings quadrangle, is likewise pre-Illinoian and formerly joined the main Rock River trench somewhere east of Rochelle. There was then no narrow rock-walled valley east of New Milford, as now, nor did the similar gorge of Rock River between Camp Grant and Byron then exist. The cause of the shifting of the stream courses will be considered under the history of Illinoian glaciation of the region.

Most of the slopes descending from the remnants of the peneplain are gentle down about to the present valley floors, but in the buried portions there are notably steep slopes. Well records show this. For example, the rock surface in Blackhawk Park is about 760 feet above the sea level, while at the Rockford Malleable Iron Works, a mile to the east, the rock surface is below 500 feet. This indicates a rather steep slope. East of Davis Junction and Holcomb and in the vicinity of Lindenwood, the buried valley seems to be below a broad and fairly plane rock surface 700 to 750 feet in altitude. Well records here also show that the slope to the valley is steeper than the slopes common to the present surface. The cover of Illinoian drift, however, renders positive statements unsafe. The above-mentioned relationships suggest that there were two partially completed cycles after uplift of the summit peneplain and before glaciation. During the first, very broad valleys were formed now represented by broad tracts 700 to 750 feet in altitude; during the second, the buried valleys, 200 feet or so deep, were eroded in this 700-750 foot surface, just before the Illinoian glaciation, by the pre-Illinoian Rock, Leaf, and Kishwaukee rivers. The inferences as to times when the region was uplifted, and when it was unaffected by diastrophism are obvious.

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[5] Leverett, Frank, U. S. Geol. Survey Mon. 38, 1899.

Pleistocene History

PRE-ILLINOIAN GLACIAL EPOCH

The Pleistocene or glacial period in the northern part of the United States was not represented by one invasion of a continental ice sheet, and its subsequent retreat. Kings quadrangle alone records the occurrence of at least three glacial epochs, and two interglacial epochs. In the states of the Upper Mississippi basin, five glaciations occurred during the Pleistocene. The ice which invaded these states came from two main centers in northern Canada (fig. 67), one in Ungava Province, on the Labrador Peninsula east of Hudson Bay, and one in Keewatin Province, west of that bay. So far as known, all the ice sheets which have affected Kings quadrangle were Labradorean continental glaciers. The maximum extension of ice from this center reached Ohio River, 1600 miles distant.

The oldest Pleistocene deposit exposed in Kings quadrangle is on the eastern slopes of Rock River valley, in the northeastern portion of the quadrangle. It is composed of fluvio-glacial gravels, now lying between 60 to 80 feet above the river. All that can be said with confidence concerning this deposit is that a pre-Illinoian ice sheet advanced into the upper drainage area of Rock River and its outwash was carried down the valley at least as far as Rockford. During both the Sub-Aftonian and Kansan glaciations, which were pre-Illinoian, glacial ice reached farther south in Iowa and Missouri than the latitude of this quadrangle, and it is possible that this region was also covered. This however is but an inference.

PRE-ILLINOIAN INTERGLACIAL EPOCH

After deposition of the pre-Illinoian gravel and before the advance of the Illinoian ice there ensued an interglacial epoch during which weathering occurred and forest trees grew in Kings quadrangle. The decayed and leached condition of the old gravel beneath fairly fresh Illinoian till is ample evidence for the occurrence of weathering of the gravel before the till was deposited. The logs and other vegetal matter reported from various wells, beneath the Illinoian till, is likewise satisfactory evidence for the existence of a flora. Presumably, stream erosion also occurred. The old drainage lines, shown on figure 69 were maintained until the Illinoian ice sheet reached the region.

ILLINOIAN GLACIAL EPOCH

The different glaciations of the northern United States have been described as though the drift sheets which record them were as continuous and as definitely separable as a group of alternating limestones and sandstones. Unfortunately, they are not. There are several reasons for this:

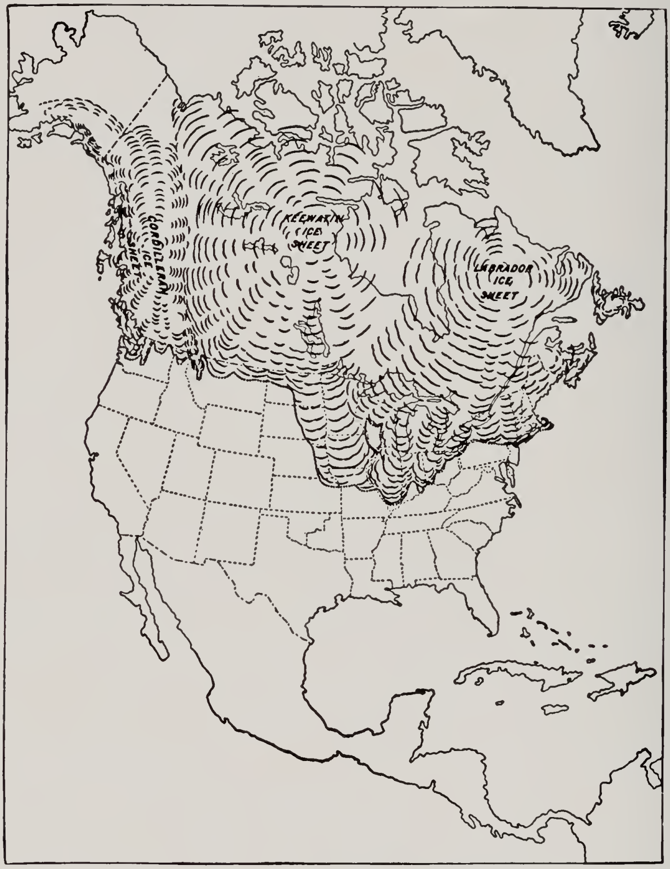

Fig. 67. Map of North America showing the area covered by the Pleistocene ice sheets at their maximum extension, and the main centers of accumulation.

(1) In most cases, the last ice sheet to invade a region destroyed all earlier glacial records. As a result, few regions have more than two drift sheets recognizable in well records, stream-cut bluffs and other sections.

(2) The older drift sheets have suffered much erosion, and they are fragmentary along their margins. The exact relationships of these separated portions are difficult to determine.

(3) Erosion has progressed at different rates in different portions of one and the same sheet of drift, because of variations in amount of rainfall and differences in stream gradients.

Due to these and other factors, there have been doubts as to the precise age of the drift in certain regions. One such region is north-central and northwestern Illinois. Leverett[6] called the glacial drift of Kings quadrangle and environs to the west, Iowan (younger than Illinoian). Later he revised this statement and called it Illinoian. Alden in his paper on "The Quarternary geology of southeastern Wisconsin"[7] describes this drift as Illinoian. But studies by M. M. Leighton of the Illinois Geological Survey have opened the question again, and his interpretations are included herewith.

The Illinoian epoch is named from the State where the drift sheet of that age is best developed. As shown in figure 68, the Illinoian drift now lies at the surface over more than half the State. Originally, it covered the area now bearing Wisconsin drift, and still underlies that drift in some places. The ice of Illinoian age in this State came from the Labradorean center. A great lobe of this glacier spread southwestward out of Lake Michigan basin as the ice sheet advanced. It pushed across the Mississippi into Iowa from a point midway between Clinton and Davenport, Iowa, to Fort Madison in the same state. The Mississippi was forced to find another course to the west of this Iowan portion of the Illinois lobe, a course which is still marked by the channel made at that time. The development of ice from the Keewatin center during this epoch, is unknown.

The direction in which the ice sheets moved is recorded by striae and grooves on the overridden bed rock surfaces. The direction varied in different localities. In general, the ice spread out fan-wise in great lobes. The Illinois lobe of this epoch moved almost directly southward in the southern portion of the State, and nearly west in the northern part. No striated surfaces are known within the limits of Kings quadrangle, but there is an excellent exposure of such a surface two miles west of Rockford, and not a mile from the edge of the quadrangle in sec. 28, T. 44 N., R. 1 E. Here the striae are W. 15° S. and record the direction of movement of the ice. Another glacially striated surface near Kings quadrangle is reported in sec. 6, T. 26 N., R. 11 E., near the village of Winnebago. The striae have the same course as in the Rockford locality.[8] It is to be kept clearly in mind that rock debris frozen in the ice, and not the ice itself, scratched, grooved, planed, and polished such surfaces.

At its maximum, the Illinois lobe extended about 60 miles west of Rockford. What the thickness of the ice was over this region during its maximum extension is a matter of conjecture. Judging from other regions

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[6] Leverett, Frank, The Illinois glacial lobe: U. S. Geol. Survey Mon. 38, 1899.

[7] Alden, Wm. C.. U. S. Geol. Survey Prof. Paper 106, 1918.

[8] Leverett, Frank, The Illinois glacial lobe: U. S. Geol. Survey Mon. 38, p. 88, 1899.

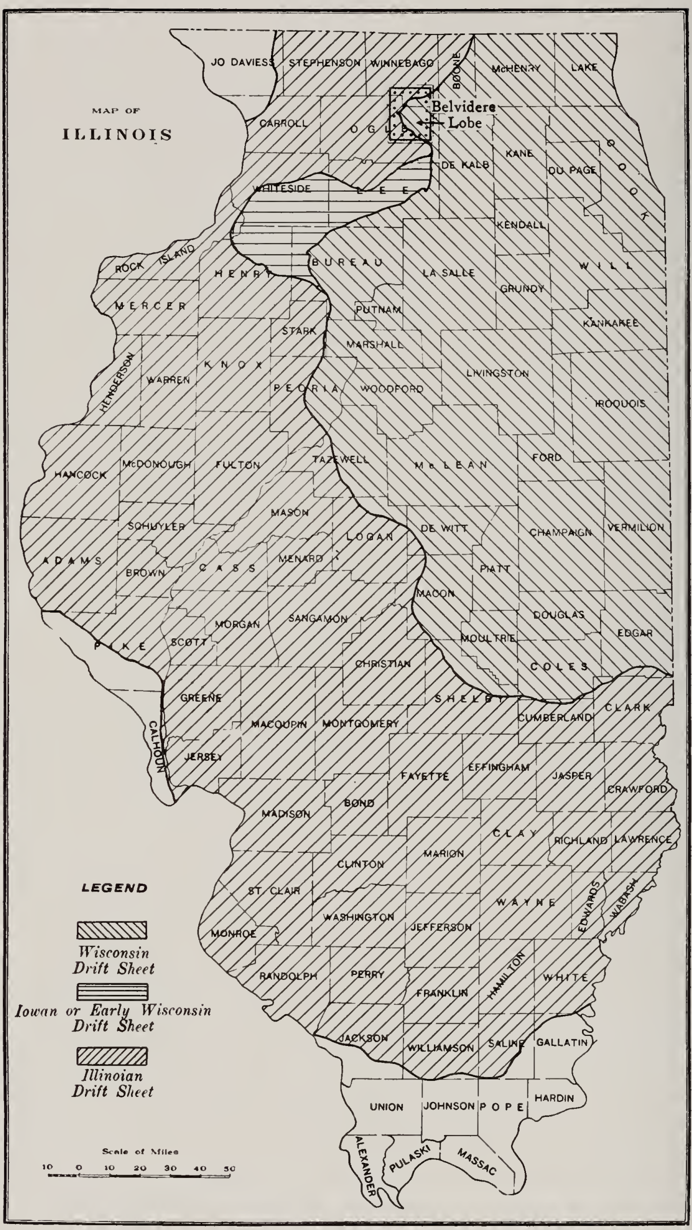

Fig. 68. Map showing glaciated area of Illinois and position of Kings quadrangle. After Frank Leverett and M. M. Leighton.

where the thickness is known, the average slope of the surface of the ice in this distance may have been 25 to 50 feet per mile. If a level base is assumed, this would give a thickness over Kings quadrangle from 1500 to 3000 feet.

Despite its great thickness and consequent abrasive power on the underlying rock, no major changes in topography resulted from glacial erosion. The debris carried to the region by the ice in its advance, was mingled with that worn from the underlying rocks to make the *ground moraine* dragged along beneath the ice sheet. This ground moraine is now but a few tens of feet deep on the slopes of the pre-glacial divides, and probably has not been eroded very much since the ice left it. Compared with the thickness of the ice itself, it was but a film of material between the nether millstone of rock, and the upper millstone of glacial ice.

Geologists are not agreed as to the cause or causes for the remarkable series of glaciations of the northern United States and other parts of the world during the Pleistocene period. Even the fact of such a series of glaciations has not been established long, nor indeed has the fact of glaciation. In an early report on the geology of Winnebago County[9] we find the following statement of opinion, less than 50 years ago:

> The drift, now the subject of grave discussion among the geologists, is very largely developed in Winnebago County. It is composed of loose, detrital matter, often of considerable thickness, brought from long distances and deposited over large areas of the county. The materials making up this loose mass were not derived, to any great extent, from the underlying rocks, but came from the metamorphic regions of the north. Whether brought by the currents and flow of the waters; or transported adhering to the sides of those slow-moving, pale green mountains, the ice bergs; or ground and pushed and moved along by creeping, all-powerful glaciers, we shall never perhaps positively know.

But it is known to-day, as well as anything which we have not witnessed is known, that a continental glacier deposited the drift. Indeed, there is less room for doubt and dispute in reading this page of earth history, than in reading most human history.

Retreat of the glacier is simply retreat of its front, and takes place because the rate of melting is greater than the rate of advance. The ice itself does not retreat as the glacier wanes under the influence of a moderating climate. Glacial retreat is slow, because climatic changes are slow. During retreat, water from the melting ice escaped across the barren wastes left exposed. In some cases the pre-glacial valleys had been filled with drift. Some of them lay at such an angle to the ice front as to be blocked with ice in their lower courses. The glacier-born streams in such cases were forced

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[9] Shaw, James, Geology of Winnebago County: Geol. Survey of Illinois, Vol. 5, p. 85, 1873.

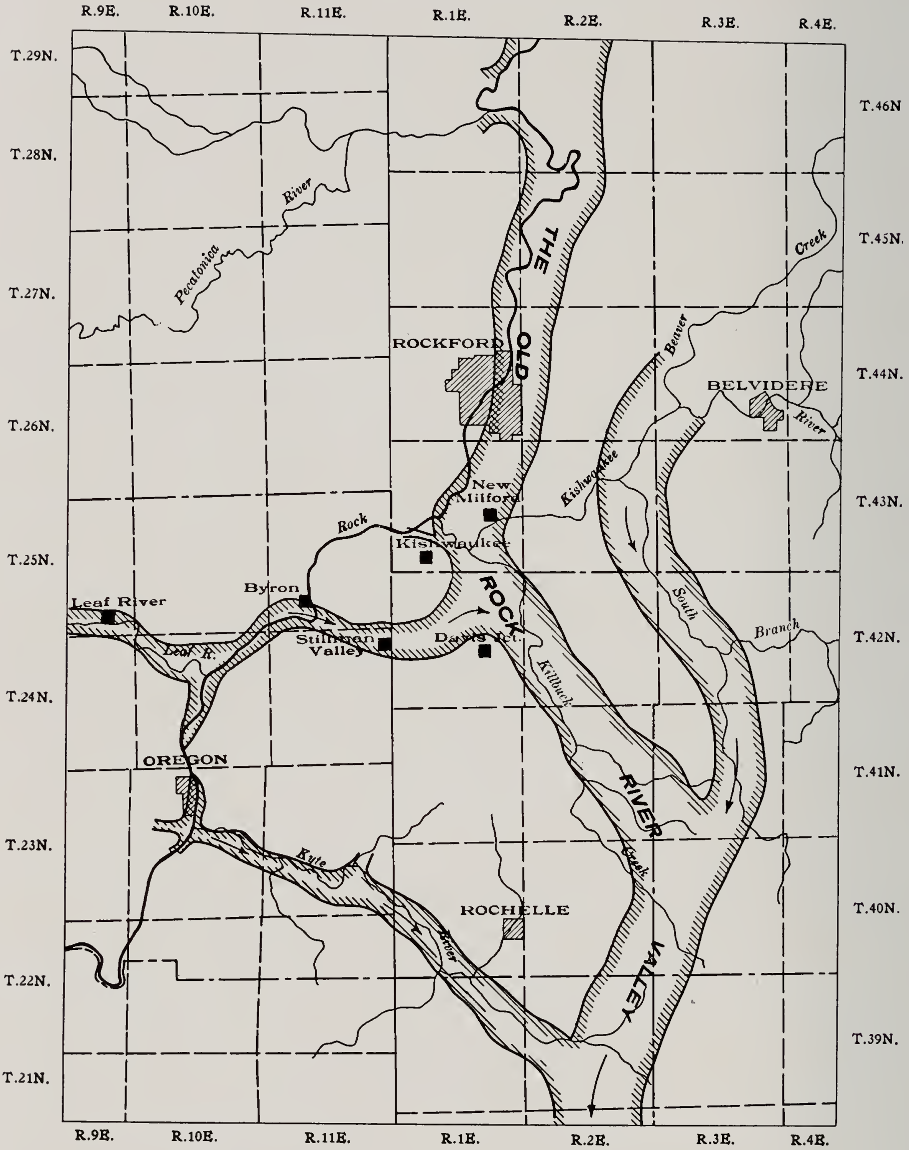

Fig. 69. Pre-Illinoian drainage pattern, superposed upon the present drainage lines.

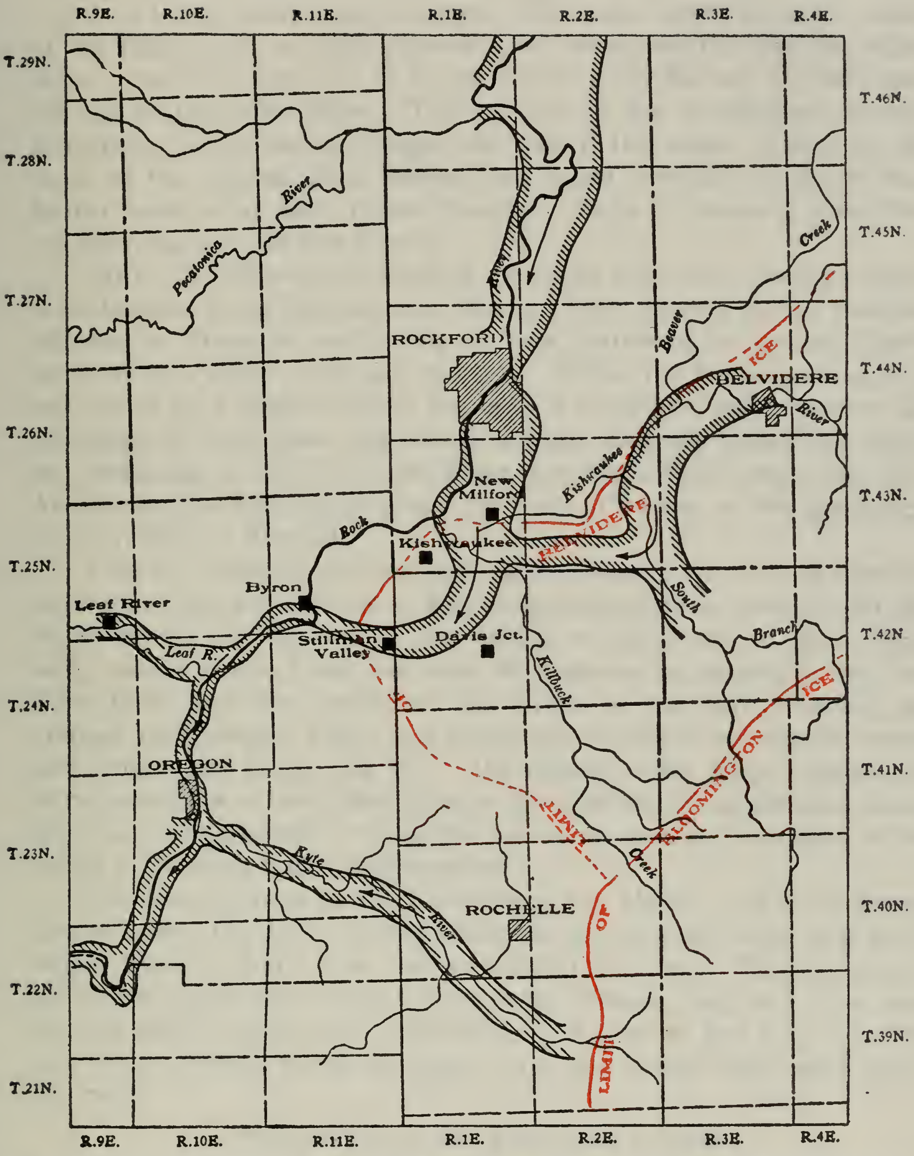

Fig. 70. Location and direction of flow of the drainage during the interval between the Illinoian and Early Wisconsin epochs of glaciation. The red line shows the position of the ice front of the Belvidere lobe when the Kishwaukee gorge and the Rock River gorge northeast of Byron were cut. Subsequently the advance of the Bloomington ice reached the position indicated.

to find new routes. These may have been used but a short time, or they may have become the permanent drainage lines of the post-glacial epoch.

Rock River suffered such a change. The present valley below the mouth of the Kishwaukee is much narrower and more youthful than the valley above. And that part down to Byron is more gorge-like and youthful than the rest of the valley below. This can not be due to difference in rock formations, for as far as Oregon, the rock is the same. It may be the result of the original divide having been higher northeast of Byron than farther south, or to more recent diversion. There is reason to think that the latter has been the true history.

Before the Illinoian ice invasion the broad Rock River valley trended south between Davis Junction and Monroe Center, passing east of Rochelle and west of Princeton, and joining the wide portion of the present Illinois valley in the vicinity of Bureau Junction. Within the Kings quadrangle it was joined by a moderate-sized tributary, Leaf River, which entered the quadrangle at Leaf River and flowed east past Stillman Valley and northeast, delivering its waters to Rock River near South Bend School (fig. 69). At this time the Kishwaukee joined the Rock to the east of this quadrangle in the vicinity of Esmond.

With the oncoming glacial climate of the Illinoian epoch, these relationships which had endured for so long were destined to be changed, for the debris left by the Illinoian ice was enough to choke the old Rock River valley south of Camp Grant and cause the waters to accumulate in the Leaf River Basin until they overflowed the divides to the south, reversing the drainage past Stillman Valley and Byron and forming a new master stream past Oregon and Dixon (fig. 70). The cutting of the gorge northeast of Byron seems not to have taken place at this time, but during the next glacial invasion, when the drift forming the low divide east and northeast of the village of Stillman Valley was deposited.

The lower portion of the Kishwaukee was blocked and the drainage, flowing across the divide at Harrisville, cut a new valley here, only to be largely filled by debris from the next glacial ice sheet. That the present Kishwaukee gorge does not date back to the Illinoian epoch is known from the fact that the pass east of Harrisville is at least 40 feet lower than the rock divide through which the gorge is cut and is filled with much softer materials.

POST-ILLINOIAN, PRE-WISCONSIN HISTORY

EVENTS IN THE KINGS QUADRANGLE

With Rock River forced to use the lower course of the old Leaf River as far as the present mouth of that stream, reversing the old direction of flow and crossing old divides to the south, and joined by the Kishwaukee west of Harrisville—this new system of drainage endured through the interval from the Illinoian epoch to the Wisconsin epoch. The change in climate from glacial to normal temperature caused the melting away of the Illinoian glacier, and the drift then became subject to erosion and weathering.

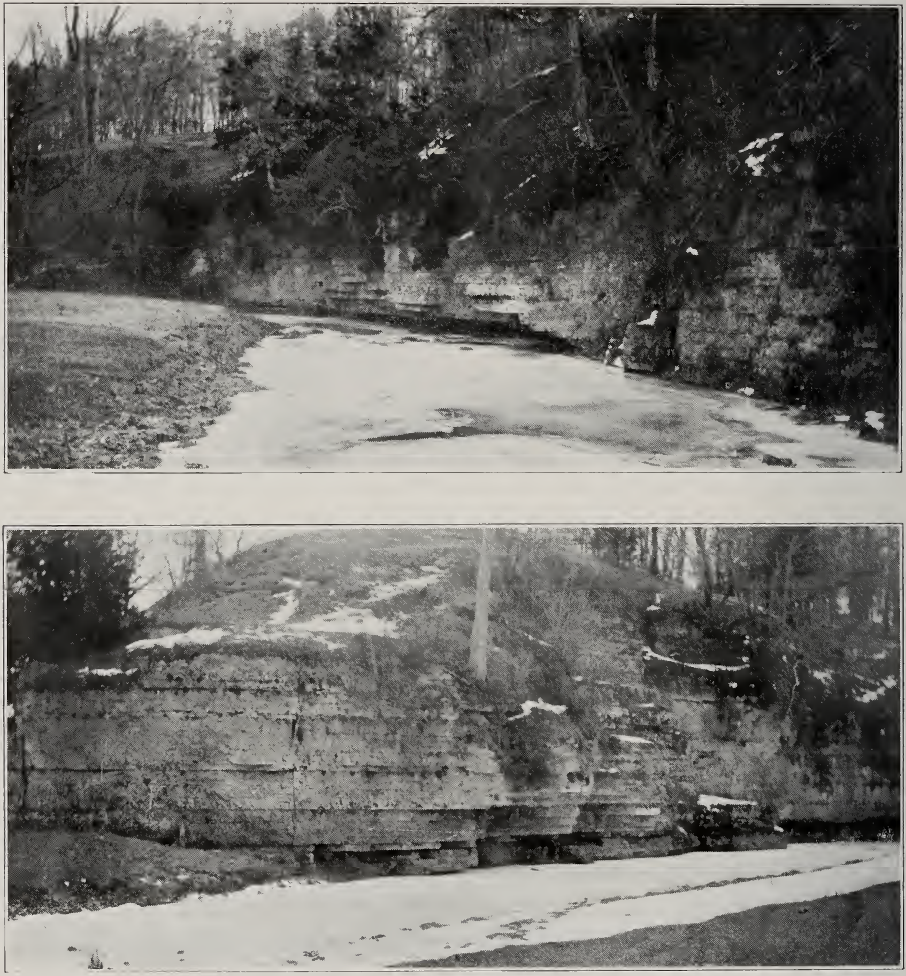

Fig. 71. Ledges of Galena limestone exposed in the post-Illinoian valley of Hall Creek.

Drift had lodged more deeply in the pre-glacial valleys than elsewhere. Though in general, pre-glacial divides still controlled the smaller drainage features, there are several cases where the minor streams, flowing again after the glacial interruption, were forced to take new courses in part. In deepening these, they found themselves superposed on rock shoulders or spurs near their former courses, and being unable to escape from such situations, they have excavated narrow gorges in the rock in such places. The "Dells," a portion of the valley of Hall Creek, six or seven miles southwest of Rockford, is a case of this sort (fig. 71). So is the gorge at the lower end of the valley which heads at Westfield Corners. Black Walnut Creek has a similar gorge. The name "White Rock" for T. 41 N., R. 1 E., in Ogle County is taken from cliffs of Galena limestone in the post-Illinoian gorge of Stillman Creek near White Rock village. In the Camp Grant range, a mile west of Gunsaulus School, there is another gorge of this sort. All these stream valleys are capacious, both above and below the constricted parts. In such wider places, they have reoccupied the pre-Illinoian courses.

Unequal deposition of Illinoian drift probably gave rise to numerous undrained depressions, which early contained lakes and swamps. These undrained tracts have largely disappeared, partly by downcutting of outlets, and partly by filling with surface wash, stream deposits and vegetal material. A very few swampy and poorly drained tracts still remain, and are shown on the geologic map (Pl. IV) as "recent alluvium" not associated with present flood plains. The filling in these depressions is not strictly alluvium; it is largely vegetal.

That the Illinoian till has been exposed to weathering for a long time is evident from a number of phenomena already described. The number and maturity of the stream valleys in this drift sheet, the absence of undrained depressions such as are characteristic of younger glacial drift, and the gentleness of slopes are in striking contrast with those of more recent glacial deposits. In addition to this is the evidence drawn from the composition of the Illinoian drift. The absence of limestone boulders on the surface, the rusty color of the upper few feet of material, the lack of calcareous material in the same upper few feet, all testify to the fact that this till sheet has been exposed to the attack of the weather for a long time (fig. 72).

Sections in the Illinoian till show different depths to which the oxidation of the iron and leaching of the limestone has gone. Such differences are due to different exposures to the action of leaching waters, and to the variations in amount of weathered material removed. This latter reason probably is the most important, and the nearest approximation to the true depth of weathering would be obtained from regions where running water has been least active. Such regions may be found on the broad flattish hilltops.

A study of the kind above outlined was made near the eastern margin of the quadrangle, along the Illinois Central Railroad. The railroad here crosses the divide between the pre-glacial Rock River valley and the pre-glacial Kishwaukee River valley. The Illinoian till on the summit of this divide constitutes a mantle a few tens of feet deep, and so little modified by transporting agencies that remnants of the original swamps still exist. The railroad cuts are from 10 to 25 feet deep, and the complete weathered zone of the till is exposed. In general, the sections are similar to those in the trenches at Camp Grant. There is a surface loam, below which is a layer a few inches thick made up mostly of gravel, and below this the reddish till grades down into the unweathered gray till. One detailed section studied is as follows:

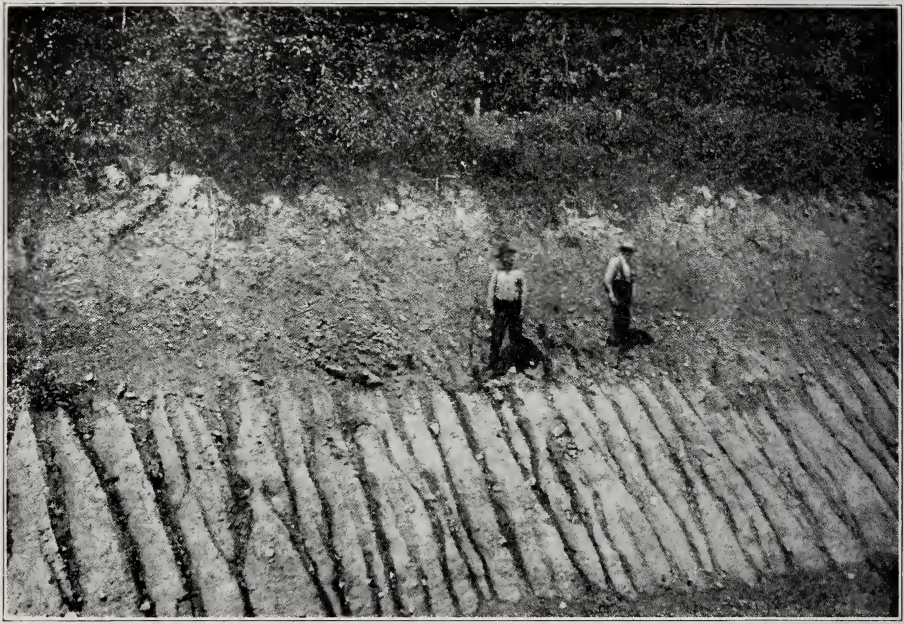

Fig. 72. Illinoian drift exposed in Chicago, Milwaukee & St. Paul Railway cut 7 miles south of Rockford. The lower part is dense calcareous unmodified boulder clay; the upper 8 feet is gravelly leached and oxidized drift; all limestone pebbles and flour have been removed from the latter by solution. (U. S. Geol. Survey Prof. Paper 106.)

		Thickness	
		Ft.	*In.*
(1)	Surface loam, without pebbles. Averages 2 feet in thickness....	2	..
(2)	Gravel and loam, the former mostly chert, forming a distinct layer below the loam and above the underlying till. Not calcareous	..	6
(3)	Till, rusty, sandy with scattered pebbles. Not calcareous.......	..	1
(4)	Till, buff and yellowish; effervesces with acid weakly at the top, and vigorously a foot below the top. Limestone pebbles abundant. Matrix effervesces more vigorously than pebbles. Down to bottom of exposure..	..	..

The upper loam member is largely a wind blown deposit, but may be in part the product of surface wash, and other surface agencies. Members

(2) and (3) are the result of weathering of the original till, such as is now exposed in the base of the cut. The rusty color and the lack of effervescence are easily explained as the result of oxidation and solution. The abundant chert pebbles require a little study. At the outset the assumption is made that the various constituents of a glacial till are pretty likely to have had a fairly uniform distribution originally.

Pebble counts were made by taking every pebble out of the rain-washed face of the slope for the same horizontal distance in each member. These, when averaged, gave the proportion of five pebbles of chert in member (3) for one pebble of chert in (4), the unweathered material at the base and of 22½ pebbles of chert in (2) for one in (4). For an explanation of this high proportion of chert pebbles in members (2) and (3), the processes of weathering should be considered. One method by which this proportion has been attained is that of concentration. Chert is insoluble in surface waters, or nearly so, and does not decompose readily. Many other constituents of the drift are either soluble, as limestone, or decompose into other substances, and thus disappear from the upper members. The prevalence of chert above is therefore not due to an increase in the amount of chert there, but to the removal of other materials by solution and decay. This results in concentration of chert in the upper part of the section. Members (2) and (3) are of the nature of *residual soil,* produced on the surface of the Illinoian till.

If this explanation alone is adopted, it may be concluded that since there are five times as many chert pebbles in (3) as in (4), the original thickness of (3) was five times its present thickness, and for (2) it might be concluded that only ⅟₂₂ of the original thickness remains.

But chert, while resistant to the chemical changes of weathering, yields to mechanical agencies and is fractured easily. The number of chert fragments, therefore, while good evidence of weathering, is not trustworthy for a quantitative estimate. The mass, or weight, of the chert taken from the different members of the section alone will give more satisfactory results in our study. Weighing the collections made in the pebble counts gave the following proportions: twice as much chert in unit volume of (3) as in (4) and ten times as much in (2) as in (4).

Since (2) is about six inches thick at present, possibly it was originally ten times as thick, or 5 feet. Since (3) is about one foot thick, it was perhaps originally two feet thick. According to this, a total of twelve feet of material has been concentrated into one and one-half feet. Ten and one-half feet of material has disappeared through the solvent action of ground water, aided a little perhaps by the action of the wind and of surface wash. This conclusion presumes that cherts were equally distributed throughout to begin with. It is to be remembered that all of this weathering had not taken place before the Wisconsin epoch, although much of it probably had. That the area was reclothed with vegetation is shown by the presence of old soil between the Illinoian drift and the overlying loess. It was perhaps near the close of this interval that much of the loess was deposited.

EVENTS ELSEWHERE IN UPPER MISSISSIPPI VALLEY

Oscillations between glacial epochs and interglacial epochs during the Pleistocene period suggest the analogy of a pendulum in moving from one extreme to another and back again. When the climatic pendulum had swung to the extreme of deglaciation, following the Illinoian epoch, a climate probably as mild as that of the present prevailed in this region. From this extreme the pendulum swung back again, and under the changed conditions of lowered temperatures and perhaps greater precipitation, the northern ice sheets again advanced southward. This time it appears that the Keewatin sheet, centered west of Hudson Bay, spread farther than the Labradorean. From the great surface extent in Iowa of a till sheet thought to have been deposited at this time, the epoch is named the Iowan glaciation. How far south the Labradorean ice extended is unknown. Apparently another swing to milder climatic conditions brought this glaciation to a close, and inaugurated another interglacial epoch, when plants and animals of a temperate climate lived and flourished in northern Illinois. But the series did not end here; for the Wisconsin glacial epoch followed.

WISCONSIN GLACIAL EPOCH

Ice from both the Labradorean and Keewatin centers invaded the United States in the Wisconsin glacial epoch. That from the Keewatin center reached central Iowa, and that from the Labradorean center crowded westward almost across Wisconsin and southwestward into Illinois, as shown in figure 68. Whatever records may have existed of Iowan ice from this center were destroyed or covered with a new mantle of drift, so far as is now known. The Wisconsin ice was notably lobed along its margin, that part reaching into Illinois being controlled by the Lake Michigan basin. The refrigeration of climate which allowed a great ice sheet to advance into this region must have had other effects. The interglacial flora and fauna were forced to abandon the region, the soil remained frozen most of the year, and precipitation was largely in the form of snow. But the chief effects which are recognizable today are the youthfulness of the topography, the freshness of the drift deposits, certain changes in drainage, and the filling of the major valleys with valley-train material.

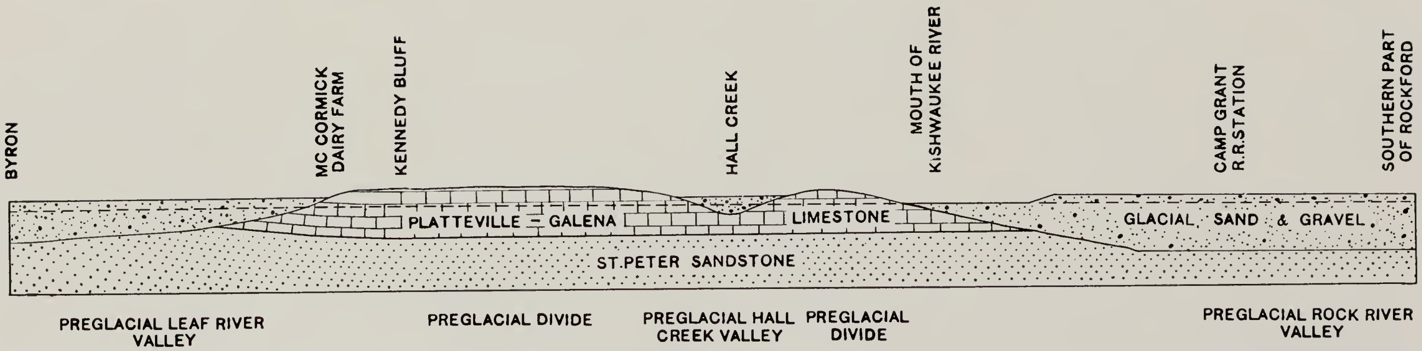

Fig. 73. Diagrammatic section between Rockford and Byron along the Rock River Valley. The broken line indicates the bed of Rock River. The summit of the profile is taken on the south side from ¼ to ½ mile from the river. The diagram shows the two pre-glacial divides which determine the rock-walled gorges and the pre-glacial valleys of Leaf River, Hall Creek and Rock River. Illinoian till is thin on the divides and is not shown.

EARLY WISCONSIN GLACIAL EPOCH

The glacial ice which moved into this quadrangle as far west as Stillman Valley in Early Wisconsin times is thought to have been a part of the same glacier which reached Shelbyville in southern Illinois.

Fresh debris was left over most of the surface covered by the ice and the topography was given a fresher contour. While the ice edge was near its maximum limit the eskerine tract north of Stillman Valley was formed, the low ridge across the old Leaf River valley was built, and the esker-like ridge southwest of Holcomb and the kame tracts northeast of Kings and north of Killbuck Creek were deposited.

The ice blocking the old Leaf River valley and resting against the hillslopes to the west, diverted the Rock across the divide east and west of the junction of Hall and Ray creeks, through which it cut rapidly by reason of its large volume, high gradient and the stoping process which is the accompaniment of the former two conditions. The topography and geology along the course of Rock River are shown in figure 73. At the same time, and also during the building of the moraine to be mentioned presently, the Kishwaukee drainage was forced across the 840-foot rock divide east of New Milford (fig. 74) which it proceeded to dissect. The full depth of the gorge may not have been cut at this time for the old valley past Harrisville was filled with drift above the 780-foot level. Indeed, the gorge was not cut below the 800-foot level while the ice was at its maximum stand for when the ice front receded to the morainic belt past Kinson School, there were two spillways, one just north of Kinson School and the other along the line of the present gorge. Obviously the latter water course gained the ascendancy. At this time, the major features of the drainage became established.

After making its maximum stand, the ice front was melted back to a zone which passes through Holcomb, west of Davis Junction and west and north of Harrisville, where it remained relatively stationary for a time long enough to deposit the moraine in this position. Big Mound and the other kames in this belt were formed at this time.

Increasing temperatures for a number of years caused the ice sheet to melt back an unknown distance from this area. But, still later in the epoch, a partial return of glacial conditions, whereby the melting did not equal the amount of advance annually, allowed the edge of the ice sheet again to move forward. It readvanced over a part of the abandoned territory but fell six or seven miles short of reaching the eastern margin of Kings quadrangle. At this stage was built the Bloomington moraine. Waters from the melting ice drained down Killbuck Creek, spreading gravel, sand, and silt, developing the feeble valley train found here. That there had been little time for

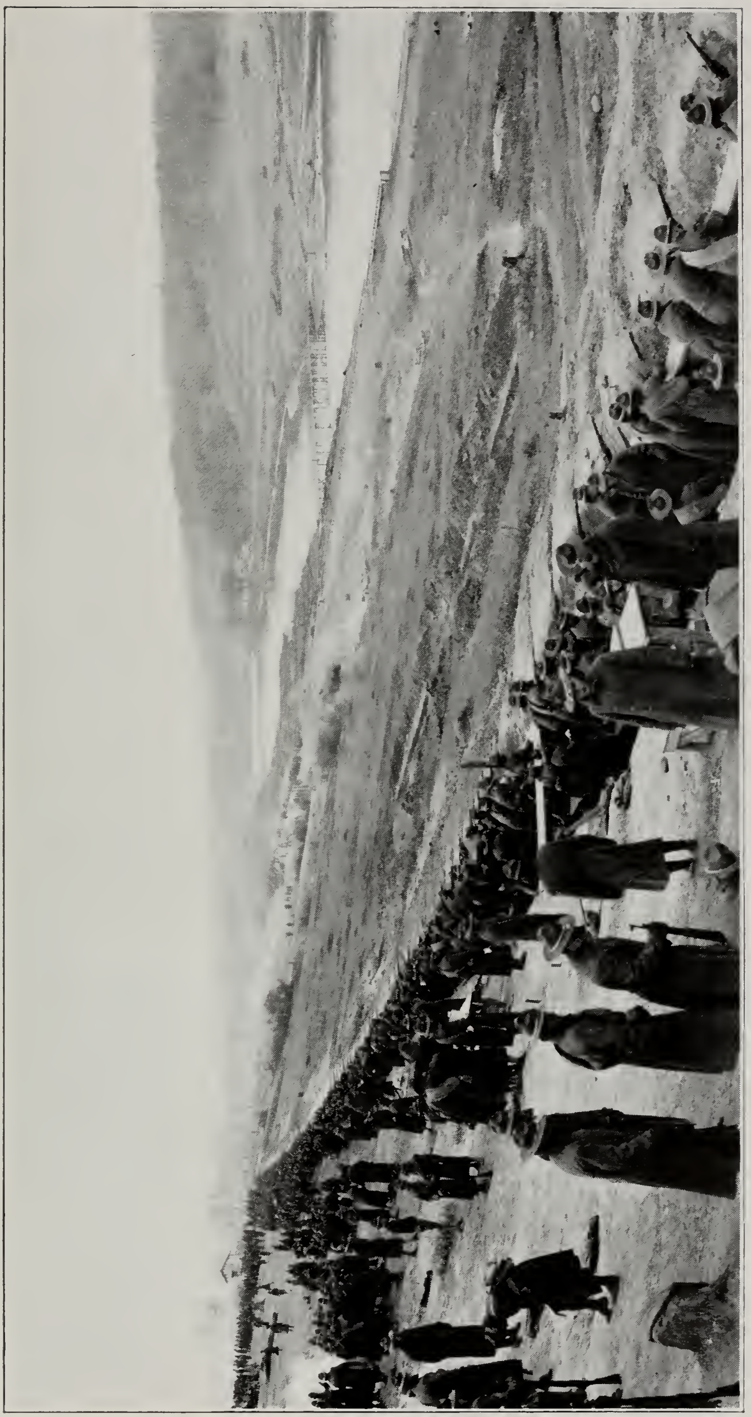

Fig. 74. Narrow valley of Kishwaukee River at the rifle range east of New Milford. Firing line at 300 yards. Rifle range, Camp Grant.

the cutting of this valley is shown by its shallow depth and the preservation of the glacial hummocks on its slopes down to its trench.

INTERVAL BETWEEN THE EARLY WISCONSIN AND LATE WISCONSIN EPOCHS

Evidence for a time interval between these two epochs has not as yet been found in Kings quadrangle, but a comparison of the kames of this area with those of the Late Wisconsin drift area farther northeast offers certain evidence of this. Next to the rock gorges, the kames and eskers of the Early Wisconsin drift are the most conspicuous topographic features of the region. They appear at first glance to have suffered almost no erosion since they were deposited by the glacial waters. But while some Late Wisconsin kames and eskers, as in Lake County, have slopes as steep as 30°, the steepest slope found on the Early Wisconsin gravelly hills of this region is 17°, and even 15° is rare. Undrained hollows are common in groups of Late Wisconsin kames, but they do not exist among these kames. Both facts indicate that there has been considerable surface creep and wash on the gravelly hills of the Early Wisconsin drift sheet, and this argues for a considerably longer exposure to the attack of the atmosphere. Less change has occurred on the gravelly drift than on the unsorted till itself, largely because the gravel is porous and absorbs the rainfall rapidly. Rivulets commonly do not form, and gullying is rare.

LATE WISCONSIN GLACIAL EPOCH

It is not known that the Early Wisconsin ice sheet entirely disappeared from northern United States and Canada before the return of a rigorous glacial climate in the Late Wisconsin epoch. It is known, however, that at least a considerable readvance of the glacier took place in Late Wisconsin times. The readvancing ice did not reach this part of Illinois, and Kings quadrangle was affected only by the deposition of valley trains. The upper 40 feet or more of gravel fill in the Rock River valley came chiefly from the Green Bay Lobe of Wisconsin, when its front stood approximately at Janesville, 30 miles north of Rockford. Most of the gravel of Kishwaukee River came from the Delavan Lobe of Wisconsin, of contemporaneous age.

The filling of sand and gravel in Rock River valley covered the low col between the rock hill of Black Hawk Park and the west valley wall (fig. 75), and the river chanced to locate here. Cutting downward, it has entrenched itself here to a depth of about 40 feet.

Two other explanations may be offered for the "Narrows" at Black Hawk Park. One is that the river was forced to take this position when the Illinoian ice, during its recession, held against the east side of the rock hill, compelling the river to cut a gorge across a rock spur. The fact that the "Narrows" is situated on the west side of the valley supports this explanation, but the force of this is lost when it is noted that rock prevails along the west side of the valley and not along the east side. Another explanation was suggested by Alden in a recent paper,[10] to the effect that the broad valley east of Black Hawk Park was filled with Illinoian till and a drift dam, rather than an ice dam, forced the river to excavate the "Narrows", and that subsequent meandering by the river and slope wash have completely destroyed this drift dam. There is no tangible evidence to support this, the valley being as wide here as elsewhere, and in both this and the preceding hypothesis the present location of the river must necessarily be referred to the Late Wisconsin epoch of gravel filling.

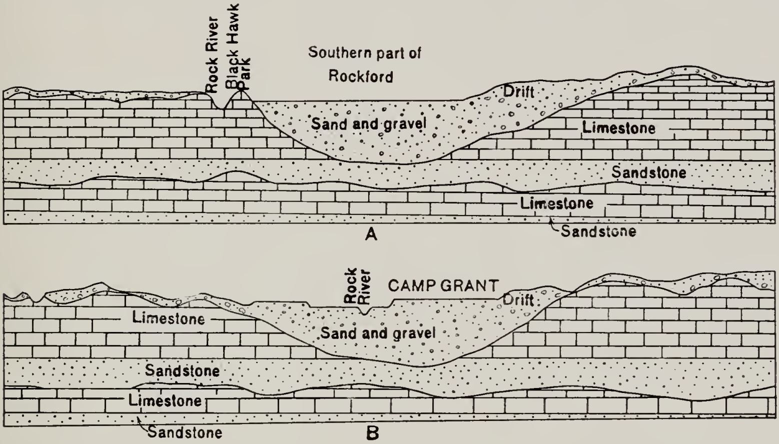

Fig. 75. Cross sections showing relations of the present channel of Rock River to the pre-glacial valley, the glacial drift, and the underlying rocks. Length of sections, 7½ miles. Vertical scale, 8½ times horizontal scale.

A. Through southern part of Rockford.
B. Through northern part of Camp Grant.

The age of the deeper part of the sand and gravel filling in the preglacial valleys of Rock River and Leaf River is unknown. It may be as old as the pre-Illinoian gravel exposed southeast of Rockford, or it may be Illinoian in age. From its washed and sorted character, it probably is a stream deposit. If Illinoian, it must have been deposited before the advancing ice reached this region, because the arrival of the ice sheet closed the history of these buried valleys, as surface drainage lines. Only the upper 40 feet or so of the 300-foot fill at Rockford, is of Wisconsin age.

POST-GLACIAL HISTORY

Changes in this region since the floods of the Wisconsin glacial epoch subsided have been almost entirely degradational. These changes are still going on. Rock River has set the pace by lowering its valley about 40 feet in the valley train. Its tributaries of course have cut no deeper. The beautiful riverward slope just west of the Camp Grant cantonment is the product of post-Wisconsin erosion. It was utilized very effectively in constructing "Grand Circle", the open air auditorium near the Red Cross building.

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[10] Alden, W. C., The Quaternary geology of southeastern Wisconsin: U. S. Geol. Survey Prof. Paper 106, 1918.

Kishwaukee River has deepened as much as Rock River, and southwest of New Milford, it has widened its post-glacial valley notably. This was doubtless done by the successive development and abandonment of great loops or meanders. The stream is still meandering on this flat, and pushing back its bluffs by undercutting on the outside of such curves.

Killbuck Creek has entrenched itself conspicuously in its valley train for only three miles above Kishwaukee Valley. Its volume is small, and its ability to erode is correspondingly slight.

Postglacial deepening by Rock River has approached closely to the bottom of the post-Illinoian parts of its valley. Widening in the drift-filled portions has made the beginnings of a flood plain. The "Grand Circle" at Camp Grant is built on this flood plain close to the foot of the bluffs of Wisconsin outwash. In some places, there are terraces intermediate in position between the terrace of the great valley train, and the flood plains. These were formed during the process of post-glacial erosion.

Weathering since the Wisconsin ice sheet withdrew has been slight. The porous outwash gravels show very little alteration. East of Kings quadrangle, where Wisconsin till overlies Illinoian, some sections show the Illinoian till apparently as deeply weathered as it is beyond the limits of Wisconsin glaciation. The Illinoian till was exposed to weathering during three Pleistocene epochs; two interglacial, and one glacial, before the Wisconsin glaciation occurred. Apparently the sum of atmospheric changes in the Illinoian till during these epochs, much exceeded such changes during and subsequent to the Wisconsin epoch.

The weathering of the bedrock, inasmuch as its composition is limestone, has been mainly that of solution by ground water. Most of the large caverns of the world have resulted from the slow process of solution and removal of calcium carbonate by ground water. In many cases the roofs of caverns have fallen in and left enclosed basins or surface depressions without visible outlet, called *sinks*. In other cases, sinks are formed by the solution of water descending from the surface along joints and other crevices. There are a few scattered examples of this work of ground water in Kings quadrangle. They will be described here though they may have been developed in part during and possibly before the Glacial period.

In the process of drilling a well at the farm house of E. W. Cleveland, in the northeastern part of the Camp Grant tract, the tools "fell off" and were lost at a depth of 117 feet, 102 feet below the surface of the rock. This well is in limestone, and the explanation offered is that a crevice or cave was encountered.

A cave "as big as a large room" is reported to exist a half mile north of Harrisville. There are three small sinks on the hill immediately west of the junction of Black Walnut and Stillman creeks. They are nearly obliterated through the accumulation of soil washed from cultivated fields. A well at the farm house here, situated on the line between secs. 4 and 5, Marion Twp. (T. 24 N., R. 11 E.) encountered a cavity at the bottom, into which, it is reported, 10 wagon loads (10 cu. yds.) of stones were thrown without filling it. Another attempt to secure a well here was made and the same cavity, filled with "black mud" was found. There is a sink at the surface 150 feet distant, probably connected with this cavern. The black mud probably was soil carried down from the surface.

There was a sink about 40 feet deep and less than 100 feet across on the same hill, about three-fourths of a mile farther south. It is now almost obliterated by filling. Eight or ten small sinks exist within another mile south. They are now indistinct, but formerly were marked features. At one time there was a rock-rimmed hole visible in the bottom of one of them. The recent obliteration of these sinks is an interesting commentary on the amount of soil wash before and since the forest was removed, and cultivation of the soil was begun.

CHAPTER V—ECONOMIC GEOLOGY

Kings quadrangle possesses no metalliferous resources. The Galena formation bears the name of the leading lead ore of commerce. It was named for the city of Galena, Illinois, which in turn was named because of the extensive occurrence of this ore in the formation in northwestern Illinois and southwestern Wisconsin. Prospecting years ago determined, however, that the mineralization does not extend into Kings quadrangle.

The non-metallic mineral resources of the quadrangle are limited to building stone, gravel, and crushed rock, for concrete and road materials, ground water, and the soils. Such of these as are transportable, are so widely distributed in Illinois and Wisconsin, that the local resources are developed for use only in the immediate region.

Building Stone

The Platteville and Galena limestones have supplied all the building stone ever taken from local quarries. The material from certain horizons near the top of the Platteville in Rockford quarries was highly prized for building purposes in former years. Today, however, the few structures in the region built of dimension stone are made of imported stone. Where local stone now goes into building construction, it is commonly as crushed rock in concrete work.

Crushed Rock

This is secured in many cases from the old quarries which formerly yielded dimension stone. Almost any horizon in the exposed limestone may yield crushed material satisfactory for concrete work and macadam paving.

Gravel

This material is used for the same purposes as crushed rock, and more extensively for road metal and railroad ballast. There are inexhaustible quantities of superior gravel in the eskers and kames of the Early Wisconsin, and in the Wisconsin valley trains. Gravel is well distributed throughout the quadrangle except in the southern portion. The southwestern part probably has in the Killbuck valley train enough gravel for road making, but it is not "bank gravel" and its excavation in the valley bottoms will be attended with difficulties from seepage of ground water. The valley train here is saturated with water almost to the surface.

Several large pits have been opened in the valley train at Rockford and Camp Grant and the gravel is wholly free from water at pit depths. Indeed, the storm waters in Camp Grant were disposed of by digging shallow wells at street corners, the porous material readily carrying off the water. The surface cover of loam is relatively impervious during heavy rains.

The largest pits of the region are the abandoned ones of the Chicago, Milwaukee and St. Paul Railway north of Stillman Valley (fig. 72) and the Chicago Great Western Railway north of Byron.

Ground Water

Springs are rare in Kings quadrangle, and the water of the streams is turbid and contaminated. Nearly all water for domestic, municipal, and commercial use is derived from wells. The most important water-bearing formations are the Potsdam and St. Peter sandstones, and the Pleistocene gravel and sand which fill the ancient Rock River valley. The more important wells of the city of Rockford Water Department are in the Potsdam sandstone. The Byron city well also takes its water from the same formation. A few industrial plants in Rockford have wells, which draw on the same source.

Some of the municipal wells of Rockford and the wells of a considerable number of this city's numerous manufacturing plants get their water from the St. Peter sandstone. Outside of Rockford, however, and excluding the region of Paines Point and the Limerick School, not more than a dozen wells in the quadrangle go down to St. Peter sandstone. Most farm wells find sufficient water in the drift, or in the limestone above the St. Peter formation.

The Potsdam formation dips gently southward from the region where it comes to the surface in Wisconsin (fig. 76). Ground water which enters it in that state descends with this formation so that in northern Illinois the Potsdam formation is saturated with water though overlain by beds which are relatively impervious. More than this, the Wisconsin region where the Potsdam is exposed is higher than northern Illinois. Such a situation, shown in figure 77, gives rise to artesian conditions; the water rises in the wells which go down into this formation above the level of the water-bearing stratum. If the head is sufficient to offset the friction caused by the movement of the water through the sandstone, artesian wells may flow. The head of wells in both the Potsdam and St. Peter sandstones is sufficient to bring water only to the level of the floodplain in Rockford. This is a rise of more than a thousand feet in some of the wells in the Potsdam sandstone.

The presence of shaly strata in the Potsdam formation determines different water-bearing horizons in it, as distinct from each other as is the St.

Peter sandstone from the Potsdam as a whole. In general, stronger flows are obtained from the lower horizons.

The Platteville and Galena limestones commonly yield enough water for farm use, though many limestone wells are reported to lower with heavy pumping, and to prove inadequate for such demands as threshing entails.

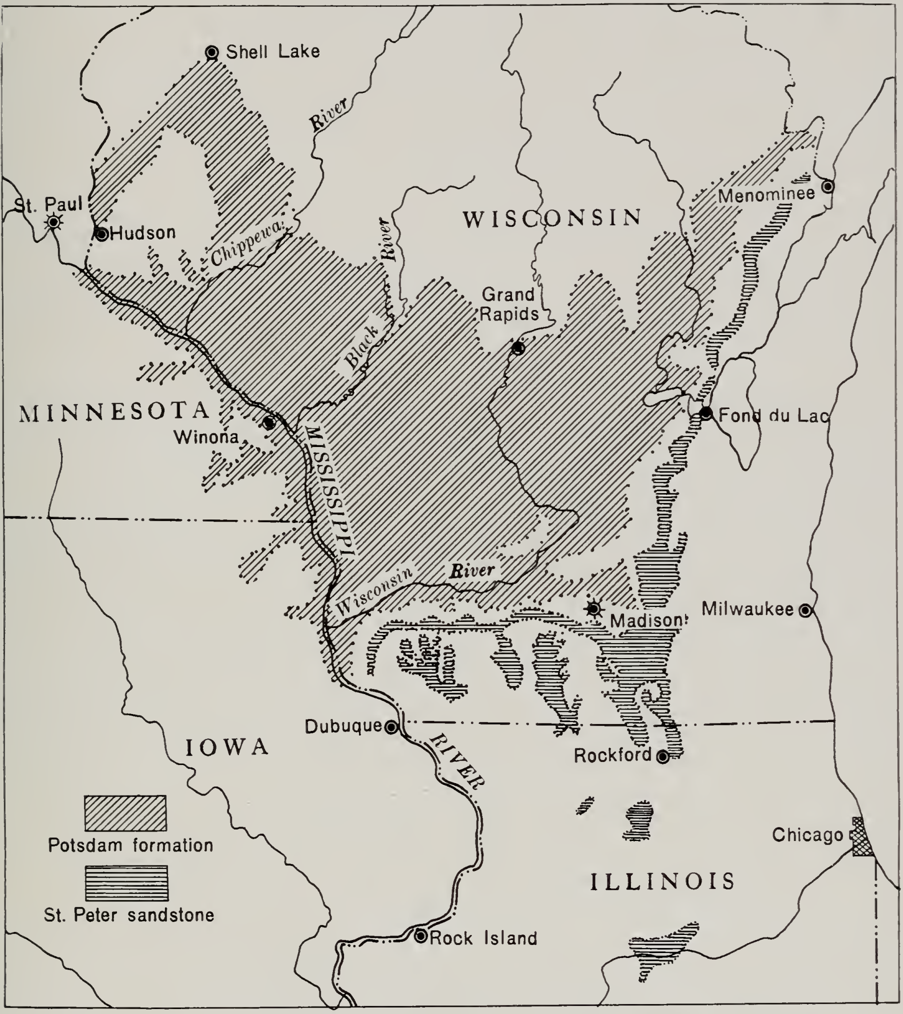

Fig. 76. Map showing outcrop of Potsdam and St. Peter formations in Wisconsin and Illinois.

There seems to be no continuity of the better water-bearing horizons in these formations, and no definite advice can be given as to location or depth required for a proposed well. Two adjacent wells may end at the same structural level, yet differ notably in amount of water obtained. The largest yield in the quadrangle from wells in these limestones is secured by the

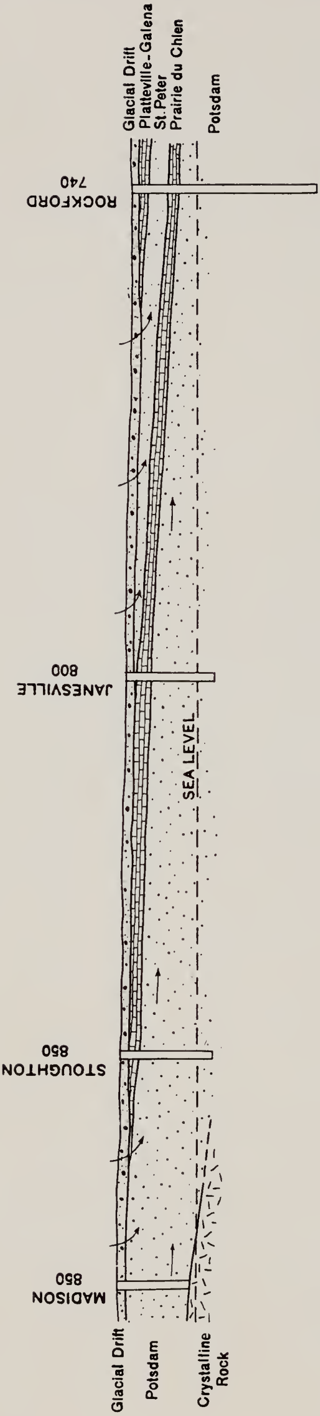

Fig. 77. Diagram to explain artesian conditions in the Potsdam and St. Peter formations beneath Kings quadrangle. Elevations indicated refer to sea level.

Chicago, Milwaukee, and St. Paul Railway, at Davis Junction. This well is 276 feet deep. It has a 5-inch casing for the last 175 feet. It yields 250 gallons per minute for 13 hours continuous pumping. The water normally stands 30 feet below the surface, and never has been lowered more than 30 feet by pumping.

Large supplies of ground water are obtained from the gravel and sand in the pre-Illinoian valley of Rock River. The total supply for Camp Grant came from eight wells drilled in this material. The deepest well goes down 185 feet below the level of the floodplain. A generalized section of the eight wells, which are grouped in a semi-circle on the floodplain, is as follows:

	Thickness *Feet*	Depth *Feet*
Sand and gravel	90-110	90-110
Clay	10-20	100-130
Sand	to bottom of wells	

The wells are artesian. The water rises from below the impervious clay stratum a little higher than average river level, but about 10 feet below the floodplain surface which here has an elevation of 694 feet. The water from these wells sufficed for a population of 45,000 men at Camp Grant. It was notably free from sulphates, a valuable feature because the sulphate scale is particularly hard to remove from boilers. Water from the St. Peter sandstone immediately below the drift here is high in sulphates. The volume of ground water in the drift-filled valley below present stream grade is doubtless far greater than that in the river itself.[1] Such supplies of ground water give rise to the common expression "a subterranean lake" or "an underground river" though in almost all cases where the terms are used, no lake or river exists; there is simply a large volume of ground water in a porous formation.

There are but three flowing wells known in the quadrangle. The White Rock flowing well is located in sec. 8, White Rock Twp. (T. 41 N., R. 1 E.). It is located on low land, is 81 feet deep and penetrates only "blue clay." Water has flowed strongly out of a pipe 20 feet above the ground. It is not far from the White Rock narrows of Stillman Creek where the surface of Galena limestone is as high as the mouth of the well. It is probable that the bottom of the well is located in the drift-filled pre-Illinoian valley of this creek.

Another flowing well, about a mile farther west and on the Third Meridian Road is 107½ feet deep, 105 feet being in blue clay. The head is insufficient to raise water to the curb, but it flows from a hole drilled through the pipe 20 inches below the curb, and drains thence to lower land. This well seems to be located over a pre-Illinoian stream valley.

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[1] Salisbury, R. D., and Barrows, Harlan H., The environment of Camp Grant: Ill. State Geol. Survey Bull. 39, p. 31, 1918.

A flowing well, depth unknown, is situated on the northern edge of sec. 9, Scott Twp. (T. 41 N., R. 1 E.), a half mile east of Little Mound. Its water is obtained from gravel.

The water in all of these wells flows from drift. Glacial drift is notably irregular in composition and arrangement, and this character may give rise to limited tracts where the water is under artesian conditions, and may flow. It is possible also that the water-bearing horizon is the contact between drift and bed rock, and the slopes of the buried pre-glacial valley may guide ground water, as they formerly directed surface water.

A few "blowing wells" and "freezing wells" exist in the quadrangle. During clear weather air is drawn down the wells, and during cloudy or stormy weather the wells commonly "blow" or exhale. Such wells are in connection with some porous or cavernous formation whose cavities are not filled with water. The atmospheric pressure is usually higher than the average during clear weather, and lower during stormy weather. The sucking and blowing of these wells are the result of equalization of air pressure in the ground with that of the atmosphere. In winter, the wells inhale air at temperatures below 32° and consequently they freeze far below the surface. One such well just north of Byron is reported to freeze to the bottom, a depth of 100 feet. All wells of this character in Kings quadrangle are in limestone.

Soils

The greatest natural resource of Kings quadrangle is its soils. Soils are varied in character, and the study of the subject involves many complex factors. Productiveness of soils varies with physical texture, mineralogical composition, organic composition, temperature, drainage, with bacteria in them, and with other factors. The most instructive viewpoint, in an elementary study of soils, is that of their origin, and this is primarily geological. The Agricultural Experiment Station of the University of Illinois has classified the soils of this region as follows:[2]

(a) Upland prairie soils, originally covered with prairie grasses. (These are on the Illinoian till sheet, but are largely loessial soils.)
(b) Upland timber soils, originally covered with forests. (Also on the Illinoian till sheet.)
(c) Residual soils.
(d) Terrace soils, largely on the Wisconsin valley trains. (Described as on "benches and second bottoms.")

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[2] Winnebago County soils: Univ. of Ill. Agr. Exper. Station soil report No. 12, p. 3, 1916.

(e) Late swamp and bottom-land soils. (These are the flood plains and other poorly drained areas.)

This classification is essentially a geological one. The soil survey has gone much further into agricultural problems than is in the province of the geological survey. The reader interested in this subject is referred to the report from which the above classification is taken.

The mineralogical composition of the upland and the terrace soils is determined more largely by the mantle of surface loam than by the nature of the underlying drift. The surface loam was derived from glacial drift, or from valley alluvium, which itself was derived from the drift. It possesses the desirable feature common to glacial soils of containing a variety of mineral constituents. But the loess-like loam has been leached of its calcareous material, as the underlying till has been, and one of its greatest needs is crushed lime rock to correct acidity. There is abundant lime rock in the region for this purpose.

Excessive under-drainage is a harmful factor in the soils on the valley trains, and the gravelly hills of Illinoian drift. In contrast with this is the excess of water in the swamp and bottom-land soils. The latter condition can be corrected by ditching and tiling, as in the upper Kishwaukee Flats, but the former condition is irremediable in this region.

Cropped and pastured soils commonly suffer in two different ways: the minerals essential for plant growth are removed in the crops, and the soil itself is removed by erosion. Application of the proper mineral fertilizers may maintain and even increase soil fertility, but if soil is removed, it can not be replaced. Ordinary slope wash from cultivated fields is serious enough, but its immediate effect on a field is slight compared with gullying. Incipient gullies may be checked by filling with brush and stones at the head, by leaving a zone of sod about them, and by encouraging the growth of grasses and bushes in them. Soil on steep slopes should be left in woodland or pasture. Even close pasturing on such slopes often will initiate gullying, and should be guarded against.

Ordinary slope wash in cultivated fields may seem negligible because its effects in a man's life time are hardly observable. Over very gentle slopes it perhaps is negligible, for the processes of soil-making on the glacial deposits of this region may about keep pace with removal. But, the whole region considered, it is a factor to be reckoned with if soils are to be preserved for the future. Rock River, as described by early settlers, was a beautifully clear stream. Since breaking of the prairie sod and removal of much of the original forest, it has become a dark and turbid stream at all seasons of the year.

This slope wash from cultivated fields can be checked very notably by plowing and working the soil approximately along contour lines. To plow, harrow, or cultivate with the slope is to facilitate the slope wash and to invite gullying; indeed, it is to make little gullies for the next rain to enlarge. Fields on the steeper slopes, if cultivated at all, should be contour-plowed.

GEOLOGY OF NORTHEASTERN ADAMS COUNTY

By Louis W. Currier

OUTLINE

PAGE

Introduction 307
Acknowledgments 307
Personnel of party 307
Field method and explanation of structure map 307
    Key horizons 308
Physiography 309
Stratigraphy 309
    General statement 309
    Unconsolidated formations 310
        Alluvium 310
        Loess 310
        Drift 311
    Consolidated formations outcropping within the area 311
        Pennsylvanian system 311
            McLeansboro formation 311
            Carbondale formation 312
            Pottsville formation 314
        Mississippian system 315
            St. Louis formation 315
            Salem formation 316
            Warsaw formation 317
            Keokuk formation 317
        Rocks known only in deep drilling 318
Relation of structure to oil accumulation 320
Possible oil horizons in this area 321
Discussion of structure 322

ILLUSTRATIONS

PLATE PAGE

VII. Map showing the structure of northeastern Adams County 308
VIII. Geologic map of northeastern Adams County 311

FIGURE

78. Index map of the area covered by this report 306
79. Diagrams showing conditions governing oil accumulation 319
80. Diagrammatic cross section showing the effect of geologic structure on oil accumulation 320
81. Diagram showing the significance of unconformities in the Colmar region ... 321

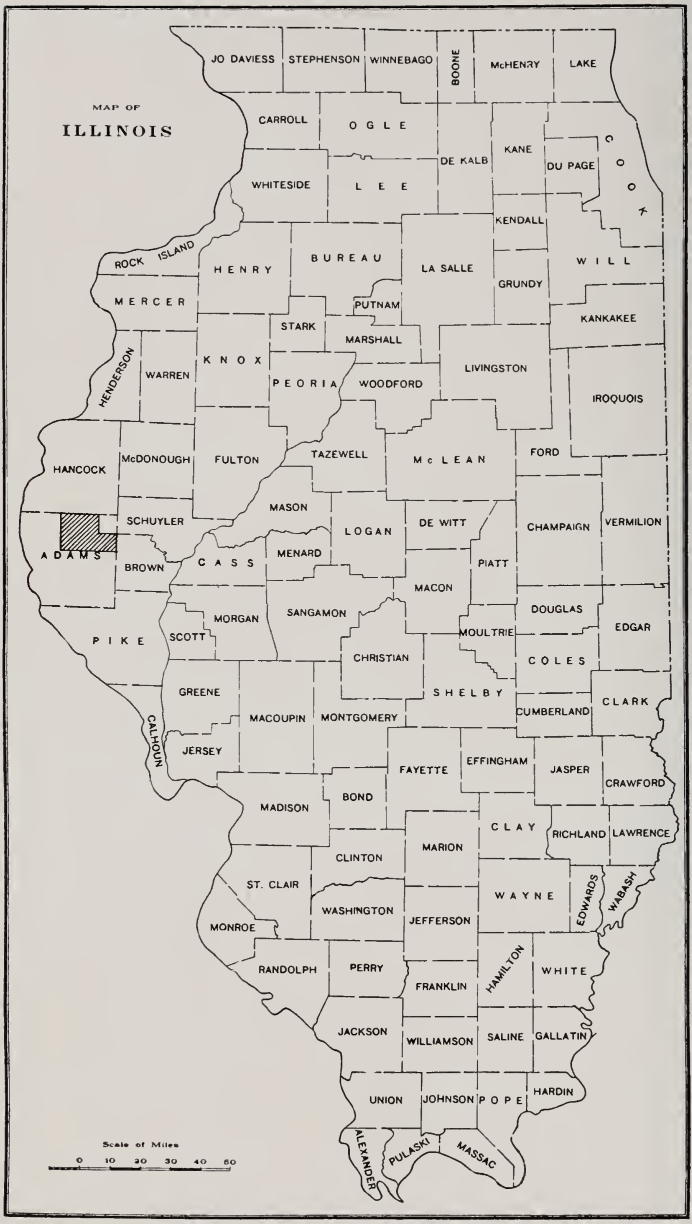

Fig. 78. Index map of the area covered by this report.

INTRODUCTION

This report embodies the results of field investigations carried on in the summer of 1919 and part of July, 1920, for the purpose of locating structures favorable to the accumulation of petroleum. The area covered comprises five townships in the northeastern part of Adams County (fig. 78), viz, T. 1 N., R. 5 W., R. 6 W., R. 7 W., and T. 2 N., R. 6 W., and R. 7 W. The region south of this area, and the region east have been studied and the results published in other Survey reports.[1,2]

ACKNOWLEDGMENTS

The writer was given a general introduction to the formations of the region by Professor T. E. Savage, who spent a few days in the field at the beginning of the work. Professor Savage was consulted several times on questions of correlation, and his valuable assistance is gratefully acknowledged.

In practically all cases, townspeople and farmers showed a pleasing spirit of interest and helpfulness, readily giving such information as they could regarding logs of drilled wells. Among them may be especially mentioned Messrs. C. A. Wever and A. Gruber of Clayton, and A. J. Clark, driller, of Quincy.

The scarcity of rock exposures makes well records of especially great value in this area, and the writer can not emphasize too strongly the necessity for keeping careful and detailed logs of drillings. It is hoped that, appreciating the possible future value of such data, farmers and drillers will take particular care to preserve logs of drilled wells whenever possible.

PERSONNEL OF PARTY

In addition to the writer, the party included Messrs. A. L. Rehnquist, instrumentman; S. T. Wallage, reconnaissance assistant; and Fred Wright and Russel Harper, rodmen.

FIELD METHOD AND EXPLANATION OF STRUCTURE MAP

The map shown as Plate V gives by means of contours the possible interpretation of the structure on the basis of field data. In the field certain formations were used as key horizons, the stratigraphic distance between them was determined as closely as possible, and elevations of outcrops of these horizons ascertained by use of the Wye level. A principal key horizon or bed was used for a basis in plotting results, and the mapped structure

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[1] Ill. State Geol. Surv. Bull. 40, Oil investigations in Illinois in 1917 and 1918, 1919.

[2] Morse, W. C., and Kay, F. H., Area south of the Colmar oil field and the Colmar oil field: Ill. State Geol. Surv. Bull. 31, pp. 6-55, 1915.

therefore is the structure of this horizon. Since in the eastern part of the area only the "Coal Measures" are exposed, the top of No. 2 coal bed was here used as the principal key horizon for the basis of that part of the structure map east of the line A-B (See Pl. VII). Figures on this part of the map represent either actual elevations of the top of No. 2 coal, or elevations of the coal as computed from determined elevations of other key horizons outcropping at these points, or from well records. For the map area west of the line A-B, the principal key horizon (the stratum upon which the structural interpretation is based) is the top of the Salem formation. Figures in this section are either actual elevations of this horizon, or computed elevations on the basis of outcrops of other key horizons (or elevations on wells in which a key horizon occurs at known depths) at these points. The stratigraphic distance between the No. 2 coal in the eastern part and the Salem formation in the western part averages 100 feet.

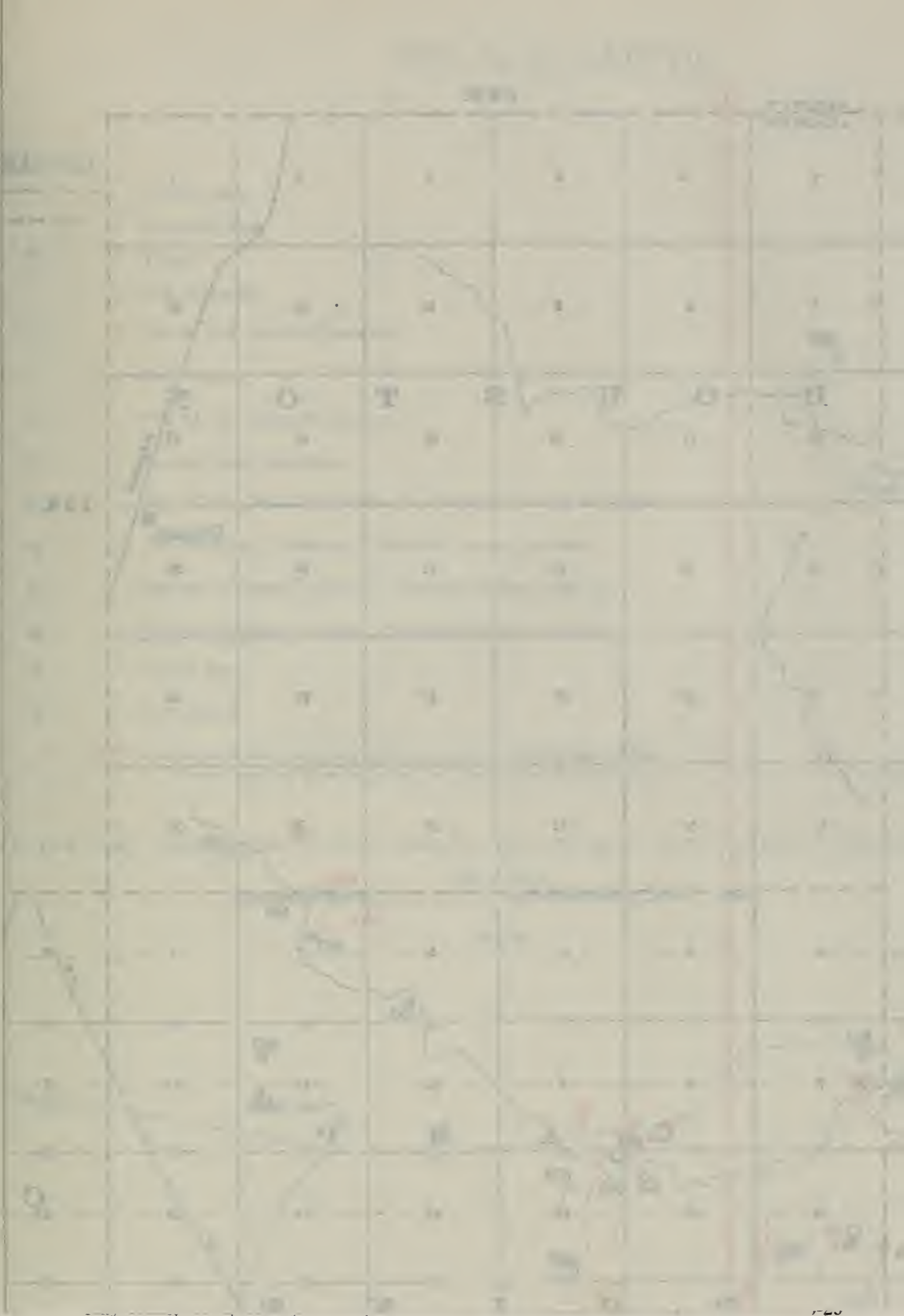
KEY HORIZONS

The following were used as key horizons:

8. Lower limestone of the Carbondale, 24 to 30 feet above top of No. 2 coal.
7. No. 2 coal, principal key horizon for eastern half of area.
6. First nodular limestone, 10 to 15 feet below top of No. 2 coal.
5. Pottsville black limestone, 23 (?) to 35 (?) feet below bottom of No. 2 coal.
4. St. Louis limestone, average 42 feet, above top of Salem limestone. Very variable.
3. Top of Salem limestone. Principal key horizon for western part of area.
2. Bottom of Salem limestone, 10 to 30 feet, average 17 feet, below top of Salem limestone.
1. Keokuk limestone, 57 to 77 feet, average 64 feet, below top of Salem limestone.

Because of the marked unconformity existing between the St. Louis limestone and the overlying Pottsville sandstone, this horizon (key horizon No. 4) could not be considered as contributing accurately to the structural data. It was made use of where some data were necessary, even though only generalized suggestions were attained by its use, and consequently its doubtful value as a key horizon should be emphasized.

The Keokuk-Warsaw contact was found at only one place. Its use as a key horizon at three other points is based on judgment as to its proximity. It is believed, on the basis of field relationships, that its use at these points is within limits of accuracy which would not seriously affect the structure as mapped.



Limestone? (not continuous)	1
Shale, black ("slate")	1½-3

is within limits of accuracy which would not seriously affect the structure as mapped.

PHYSIOGRAPHY

The greater part of the area is undissected prairie of the usual monotonously level type. It is drained by very minor creek branches of Mississippi and Illinois rivers. In the eastern part the only valley of importance is a branch of Crooked Creek (Brown County). In places the south wall of this valley is steep, erosion having exposed a precipitous bluff of Carbondale shales. The north side of the valley rises more moderately and uniformly to the general prairie level. The valley of Bear Creek and its branchs drains most of the western half of the area into Mississippi River. The western part of this drainage area displays a comparatively rugged topography, developed partly in bed rock and partly in a thick drift mantle.

STRATIGRAPHY

General Statement

In addition to the recent alluvium and Pleistocene drift and loess, the formations exposed in this area are confined to the Pennsylvanian and Mississippian systems. The rocks of the eastern half are entirely Pennsylvanian, while in the western half the two systems are present in approximately equal amounts. Between the two systems, a very strong erosional unconformity exists, i. e., the contact between the Pottsville sandstone and the St. Louis limestone. Consequently, the structures mapped on "Coal Measures" horizons may not reflect exactly the structures of lower beds, although probably no material error is introduced by assuming a general parallelism to exist between the Mississippian and Pennsylvanian beds.

General columnar section of rocks exposed in area

	Thickness *Feet*
Quaternary system	
Recent	
Alluvium, variable; probably up to	20
Pleistocene	
Loess, variable; up to	10±
Drift, extremely variable; up to	100±
Pennsylvanian system	
McLeansboro formation	
Fusulina limestone and underclay	indeterminate
Unconformity	
Carbondale formation	
Shale, blue	50-65
Sandstone, shaly and calcareous	10-12
Limestone with much chert	2- 4
Clay-shale, blue, sandy at top	20-25
Limestone? (not continuous)	1
Shale, black ("slate")	1½-3

General columnar section of exposed rocks—Concluded

	Thickness *Feet*
No. 2 coal	2- 3
Underclay and clay-shale	10-15
Pottsville formation	
Limestone, nodular	1½
Shale-sandstone series, with several conglomeratic zones which are probably not continuous	21
Shale, blue	3
Limestone, black	1
Sandstone, platy	7
(Interval?)	
Sandstone-shale series becoming white sandstone at base, not less than	8
Unconformity	
Mississippian system	
St. Louis limestone	
Limestone, white, dense, brecciated, variable up to	48
Limestone, brown, dense	
Limestone, platy and brecciated	
Salem limestone	
Limestones, generally non-fossiliferous, compact, platy, dolomitic, and associated shaly limestone and calcareous shale beds	11-30
Warsaw shale	
Shales, blue, geodiferous, with numerous thin, platy limestone partings, especially near top	45-50
Keokuk limestone	
Limestone, gray, fossiliferous, somewhat crystalline, containing numerous chert layers. Base unexposed. About 15 to 20 feet exposed in area.	Indeterminate

UNCONSOLIDATED FORMATIONS

ALLUVIUM

Stratified muds, sands, and gravels have been deposited along the present stream courses as stream-beds, flood-plains, and terraces. These are of variable thickness, ordinarily about ten feet but locally they may be much thicker. The deposits are nowhere extensive, being confined to a narrow valley zone immediately adjacent to the creeks.

LOESS

The loess formation covers the glacial drift in many places, and often over extensive areas. It consists of a four to ten foot bed of very fine sand believed to be a wind deposit formed immediately subsequent to the withdrawal of the Pleistocene ice-cap; that is, it is considered the result of wind and clay intimately mixed, and remarkably uniform in texture. It is generally

action upon the newly formed drift sheet. Because of its uniform clastic texture and its partially argillaceous composition, it appears in steep-sided banks where roads or stream courses have been cut through the deposit.

DRIFT

The drift deposits are present throughout the area forming a continuous layer except where subsequent erosion has removed small patches and exposed the underlying consolidated formations of limestone, shale, and sandstone. This glacial material consists of a heterogeneous mixture of clay, sand, and gravel, for the most part entirely unassorted. Boulders of the underlying formations and of formations outcropping outside the region are plentifully scattered through the drift. Although the upper surface of the drift sheet is remarkably level, forming the characteristic prairie-land topography, the lower surface, in contact with "bed-rock" formations, is extremely uneven, causing considerable variation in the thickness of the drift. Judging from well records, it sometimes attains a thickness of 100 to 150 feet in places, and although its average is 40 or 50 feet, it is known to decrease to 30 feet. Shallow water wells obtain their supply from sandy portions of this drift.

Consolidated Formations Outcropping Within the Area

PENNSYLVANIAN SYSTEM

MCLEANSBORO FORMATION

The McLeansboro formation is represented by a very small patch of limestone and shale, in secs. 13 and 14, T. 1 N., R. 5 W. The distribution as inferred from the three outcrops observed will be seen by referring to the geologic map (Pl. VIII). The exposures consist of a thin limestone bed, ½ to 1½ feet thick, below which are two or three feet of greenish-blue clay, mottled in appearance, and containing a ¼-inch layer of very black clay. At one exposure numerous small ovoidal calcareous nodules are found in the clay a few inches below the limestone. Recognition of the limestone as belonging to the McLeansboro formation is based upon Professor Savage's identification of the fossil *Fusulina* (*Girtyina*) which is fairly abundant in it. The limestone is compact, and a fresh surface is usually light gray in color, but upon weathering the color changes to light brown and the weathered exposure has a nodular appearance.

The McLeansboro limestone rests unconformably upon the Carbondale shales. At one locality, the vertical distance between the base of the No. 2 coal and the McLeansboro limestone appears to be about 95 feet, while a third of a mile southwest the interval probably does not exceed fifty feet. Thus the unconformity is marked and consequently the McLeansboro limestone can not successfully be used as a key horizon in plotting the structure of No. 2 coal. The bed probably corresponds to the usual McLeansboro horizon just above No. 6 coal in other localities, although no equivalent of this coal was found in the area under discussion.

CARBONDALE FORMATION

The major part of the Carbondale formation in this area consists of a thick shale bed upon which the Fusulina limestone described above rests. The erosion interval between the Carbondale and the McLeansboro formations causes considerable variation in the thickness of the former. A composite section of the Carbondale follows. Nowhere may a continuous outcrop be traced from the base to the top of the Carbondale.

Composite section of Carbondale formation

	Thickness
McLeansboro formation	
Carbondale formation	*Feet*
Shale	12 to 15
Sandstone, partings shaly	1 to 2
Shale, blue, weathering greenish (several concretionary and septaria beds about 1 inch thick near base)	52
Sandstone, shaly or platy, calcareous	12
Limestone, crinoidal, cherty at top	2 to 3½
Shale, arenaceous	2
Shale, blue	20±
Limestone (not continuous)	1?
Shale, black, carbonaceous; "black slate," very fissile	1½ to 3
No. 2 coal	2 to 3
Underclay and blue clay shale	10 to 15
Pottsville formation	

The thick shale bed at the top of the Carbondale column outcrops at many places throughout the easternmost township (T. 1 N., R. 5 W.). Exposed banks of the shale are light bluish-gray where the surfaces are fairly fresh, but outcrops of long exposure have a distinctly greenish hue. The weathered rock shows it to be slightly micaceous and sandy in local portions. Sandy layers are often prominent as thin partings or as lenses up to two feet in thickness, especially in the upper half of the shale bed. Portions of the shale frequently display prominent spheroidal concentric cleavages of striking perfection in addition to the normal bedding cleavage, so that when seen at a short distance, the bed gives the impression of containing boulders similar in color to the surrounding shale material. Stratification markings pass without apparent change into and through the spheroidal masses. The base of this thick shale bed is exposed only in two places, NE. ¼ and NW. ¼ sec. 14, T. 1 N., R. 5 W. At both exposures four apparently persistent concretionary layers are to be seen near the base. Each of these horizons is about one inch thick and composed of a single layer of ovoidal masses whose greatest diameters are from two to three inches. The majority of them are of septarian structure either slightly or well developed. The interval between layers is from six to eighteen inches.

The shale bed above described rests upon ten to twelve feet of coarser material, usually sandy and calcareous but variable in texture and composition. It possesses a bedding cleavage which gives a platy appearance to the fresh outcrop, the plates being usually under one inch in thickness. In color it is light gray to almost white, with very short black streaks throughout. Upon weathering this horizon develops into a very porous, friable, light-brown sandstone, resembling rather closely the sandy lenses common near the top of the shale bed above.

The limestone below the platy sandstone was found in a series of exposures only along the creeks in the southern part of sec. 12, T. 1 N., R. 5 W. It is easily recognized in these places because of a prominent development of chert in the upper portion of the bed. The section at one of the exposures follows:

Section at exposure of key horizon No. 8 (p. 308) at about center SW. ¼ sec. 12, T. 1 N., R. 5 W.

	Thickness	
	Ft.	*In.*
Shale, very sandy, and platy sandstone, calcareous	3	..
Limestone, compact, crinoidal, with much chert in upper half	3	6
Clay shale, thinly laminated, dark brown (contains crinoid stems, and pebbles of black limestone)	..	6
Limestone, black	..	1
Clay, black ... up to	..	1
Shale, blue, very sandy	2	..

This limestone would serve as an excellent key horizon, and was used as such in this work, but outcrops of it are scarce in this region. It apparently corresponds to the second nodular limestone (key horizon No. 5) of Nebel's Brown County report.[3]

No. 2 coal is well exposed at only two places in the area. At one of these, NW. ¼ sec. 24, T. 1 N., R. 5 W., it is immediately overlain by two feet of black shale. The further upward succession is not disclosed. At one place in the NW. ¼ sec. 16, T. 1 N., R. 6 W., at least three or four feet of blue shale intervenes between the black shale ("black slate," so-called) and the coal, while at a nearby point (NE. ¼ sec. 17) the black shale rests directly upon the coal.

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[3] Nebel, Merle L., Brown County: Ill. State Geol. Survey Bull. 40, p. 24, 1919.

POTTSVILLE FORMATION

The Pottsville formation is sandy for the most part, contrasting with the shaly character of the Carbondale. Locally within the Pottsville, non-persistent conglomeratic portions are found which often enclose fragments of coal and of fossil Calamites. Thin shaly layers, usually as partings, are to be found in the sands. Parts of the Pottsville sands are distinctly shaly, due to an abundance of mica flakes. Limonitic concretions and streaks are very common. At the base, where the Pottsville rests unconformably on the St. Louis limestone, the sandstone commonly becomes very uniform, less micaceous, and nearly white.

The following sections illustrate the lithologic and variable characteristics of the Pottsville.

Exposure of Pottsville formation in SW. ¼ sec. 18, T. 1 N., R. 6 W.

	Thickness *Feet*
Sandstone, white, fairly massive, platy in parts	1½
Shale, blue clay, arenaceous at top	2
Sandstone, platy white	2½
Sandstone, much limonitized zone of	1 to 2
Shale, arenaceous	2½
Unconformity	
St. Louis limestone	..

Exposure of Pottsville in SE. ¼ sec. 3, T. 1 N., R. 6 W.

	Thickness *Feet*
Sandstone, massive, platy, and shaly in parts, with abundance of mica; limonitic streaks and nodules	15±
Sandstone, conglomeratic, with coal fragments and fossil plants. Of variable thickness; maximum	2
Shale, bluish clay	1½
Limestone, fossiliferous, black, sandy in portions	1½ to 2
Sandstone, platy, well laminated, light bluish (bottom not exposed)	7+

No continuous outcrop can be traced between the base and top of the Pottsville formation; consequently its total thickness is indeterminable except as suggested by imperfect well records and by combining results of scattered exposures. The unconformity at the base is very marked, Pottsville sands occupying the deeply trenched St. Louis limestone, giving the Pottsville a variable thickness. A general average for its thickness is apparently about 40 feet. A composite section follows:

Composite section of Pottsville formation exposed in northeastern Adams County

	Thickness *Feet*
Carbondale	
Coal No. 2	
Clay shale (maximum)	15
Pottsville	
Limestone, nodular	1½
Shale, arenaceous	2
Sandstone, conglomeratic locally	2
Sandstone	15
Sandstone, conglomeratic locally	1½
Shale, blue	1½ to 4½
Limestone, black	⅔ to 1½
Sandstone, shaly	7
Shale, arenaceous	2
Sandstone, platy, white; shaly in places	7?

MISSISSIPPIAN SYSTEM

ST. LOUIS FORMATION

The St. Louis and older formations are exposed only in the western half of the area explored. As stated above, its upper contact is extremely irregular. Its lower contact, on the other hand, is very regular for the most part. The formation is readily recognized in the field, and in a general way comprises three distinct phases. The upper and thickest bed displays a highly brecciated and thoroughly consolidated white or light-gray limestone. It is so compact that in most cases its brecciated character is clearly brought out only on weathered surface. The fragments are greatly variable in size and shape, and degree of angularity. The limestone itself is very dense and irregularly bedded. Fossils are very rare, but occasionally species of the coral *Lithostrotion* are found. Very thin seams and small patches of greenish shale occupy spaces between the fragments. Below the upper, highly brecciated bed appears a light to medium-brown magnesian limestone, 7 to 10 feet in thickness. The upper half of this bed is much brecciated and extends irregularly into the uppermost St. Louis bed described above, making an unconformable relationship between the upper and lower St. Louis members. The basal member of the St. Louis formation consists of two or three feet of compact white limestone, less brecciated than the upper member, but with an additional platy structure parallel to the bedding planes. Its lower surface rests upon Salem limestone.

A section measured in SE. ¼ sec. 8, T. 1 N., R. 7 W., follows:

Section of the St. Louis limestone formation in SE. ¼ sec. 8, T. 1 N., R. 7 W.

	Thickness *Feet*
St. Louis limestone, white, highly brecciated	25±
Limestone, compact, slightly fossiliferous, and slightly crystalline, weathering to a brown color; brecciated in upper portion	7 to 10
St. Louis limestone, platy, white	2
Salem limestone	

The St. Louis formation is variable in thickness; measurements taken showed limits of 26 and 48 feet. Because of the very marked unconformity between it and the overlying Pottsville, the thickness is believed to have much more variation than these measurements would allow.

SALEM FORMATION

A slightly unconformable contact exists between the St. Louis and Salem limestones. The Salem served as the principal key bed for the western half of the area and the structural contours are based upon its upper contact.

Lithologically, the Salem formation consists of fine-grained, compact, practically non-fossiliferous, dolomitic limestone and shale. It is easily distinguished from the overlying St. Louis by the absence of brecciation, and by its characteristic greenish-gray to dark-gray color. Parts of the formation, especially the uppermost portion, possess rock cleavages whereby thick plates of the rock 1½ to 2 inches thick, are normally formed. Occasionally the upper portion becomes crystalline limestone, but more commonly it is rather earthy in appearance and in places sandy. The lower portion of the formation is predominantly shaly. The following typical section is continuous with the St. Louis section given above.

Section of Salem limestone formation in SE. ¼ sec. 8, T. 1 N., R. 7 W.

	Thickness *Feet*
St. Louis limestone, platy and brecciated	1⅔
Salem formation	
Limestone, dolomitic, greenish gray and earthy in appearance; breaks into plates 1 to 4 inches thick; upper portion weathered brown and sandy	4
Shale, blue clay	1½
Limestone, shaly	1
Shale, thinly laminated, grading from above	⅚
Limestone, argillaceous, platy; plates thin	1
Shale, thin, blue	2

The base of the formation is shaly and sometimes very difficult to trace because of its similarity to Warsaw shales. The total thickness may be as great as 30 feet, according to one measurement, but in general it is from 12 to 20 feet.

WARSAW FORMATION

The Warsaw shales have an average thickness of 45 to 50 feet. The formation consists chiefly of light bluish-gray clay shales, containing numerous shaly limestone partings. The upper portion of the bed, for a variable thickness, is essentially composed of blue-gray, thin-bedded limestone almost shaly in character, the thin plates formed by weakness along the bedding planes having a thickness of usually less than an inch. The limestone is highly fossiliferous, the fossils being mostly bryozoans. The genus Archimedes is quite abundant and the species *A. owenana* and *A. wortheni* common, the former being confined to the Warsaw or younger formations, according to T. E. Savage. The limestone horizon of the Warsaw grades into blue shale below and the latter contains thin lenticular beds and partings of the limestone, apparently with no definite frequency or vertical restriction, but more abundantly in the upper portions. Horizontally, a change from simple shales to shaly limestone may be seen within a very few rods. On the whole, the Warsaw in this region is predominantly blue shale in which geodes are so abundant that the term "geode shales" is commonly and aptly given to the formation. Geodes seemed to be more abundant in the middle and upper portions, and, while dispersed in places, are more commonly arranged in beds. The majority of the geodes have diameters of less than six inches although some of greater diameter are to be seen.

The greatest observed thickness at any one exposure examined was 28 feet, of which the upper 8 feet consisted of platy limestone which weathered brown. Fresh surfaces of the limestone consistently display a blue-gray color. No continuous exposure from the base to the top of the Warsaw was found. The total thickness as stated above, is a judgment based on comparison of various exposures.

KEOKUK FORMATION

The Warsaw shales rest upon a more massive limestone, of partially crystalline character, which has been assigned to the Keokuk horizon on the basis of its fossil content and marked lithologic difference. The actual contact was seen at only one place (NE. ¼ sec. 30, T. 2 N., R. 7 W.), and at this place appears clearly defined without any marked unconformability.

The Keokuk limestone is lighter gray color than the Warsaw and buff-colored where weathered. Its crystallinity is marked in some places. Chert layers are prominent. The formation is best recognized, however, by its type fossils, viz., *Spirifer keokuk, Reticularia pseudolineata,* and *Orthotetes keokuk.* Other common fossils are species of the cup coral *Zaphrentis,* of the brachiopods, *Spirifer suborbicularis* and *Spirifer neglectus,* and abundant bryozoan fragments.

The Keokuk is the oldest formation exposed in the area and its thickness is undetermined. Probably 25 to 30 feet is exposed. A few well records available would give an inferred thickness in this area of 100 to 125 feet, though in drilling the underlying Burlington limestone could easily be confused with the Keokuk and a large part of this thickness may possibly be referred to that horizon. In adjoining areas to the south and east the thickness of the Keokuk is stated to be 24 to 75 feet.[4]

ROCKS KNOWN ONLY IN DEEP DRILLING

The base of the Keokuk limestone is not exposed within the area. It is not possible to state its thickness on the basis of data collected in the area under discussion. Below the Keokuk the sequence of formations is as follows:

Record of strata below the Keokuk limestone in northeastern Adams County

	Probable range of thickness *Feet*
Mississippian system	
Burlington limestone	
Limestone, light gray, partly crystalline, fossiliferous, with numerous chert layers	80 to 100
Kinderhook shales	
Shales, gray or light blue (drill records may not differentiate this from the underlying Upper Devonian shales)	80 to 125
Devonian system	
Upper Devonian	
Shales, brown	20 to 170?
Devonian-Silurian	
Limestones, dolomitic	
Hamilton limestone (Devonian) and Niagaran limestone (Silurian) usually grouped as "second lime" of drill records. Found wanting in well in sec. 22, T. 1 N., R. 5 W.	75 to 100?
At the base of the Niagaran limestone there occurs a thin porous sandstone, not continuous but rather as isolated patches whose thickness varies from a few inches to 30 or more feet. This sand formation forms the oil reservoirs of the Colmar field and is known as the "Hoing sand." The Niagaran limestone just above is porous and furnishes the gas of the Pike County gas field.	
Ordovician system	
Maquoketa shale	
Shales, mostly gray, containing some thin limestone beds or partings	160 to 200
Kimmswick-Plattin limestone	200 to 300
St. Peter sandstone	
Sandstone, pure, white; furnishes abundant water in places	

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[4] Ill. State Geol. Surv. Bull. 40, Oil investigations in Illinois in 1917 and 1918, pp. 28, 88, 1919.

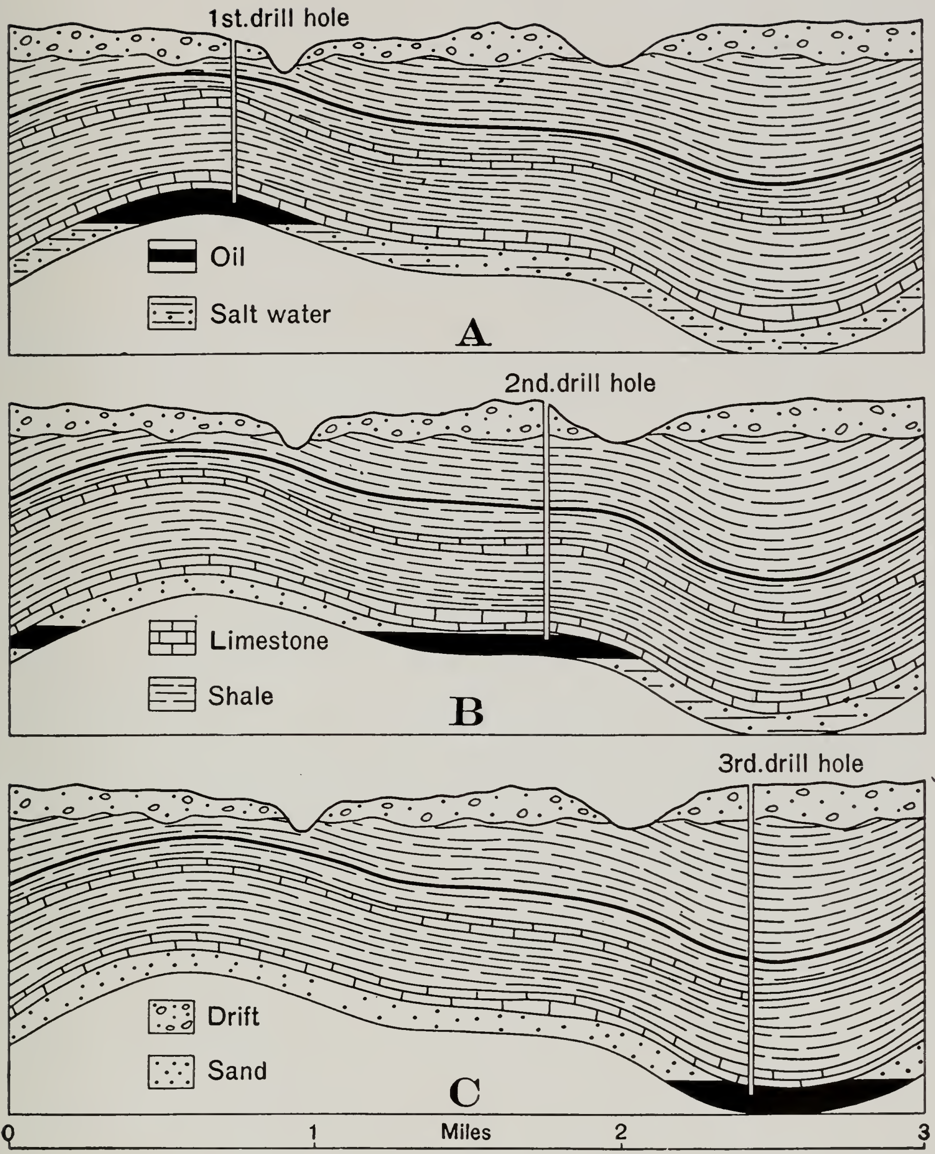

Fig. 79. Diagrams showing conditions governing oil accumulation.
A. In oil sands saturated with water.
B. In oil sands partly saturated.
C. In sands containing no water and only partly filled with oil.

RELATION OF STRUCTURE TO OIL ACCUMULATION

The following geologic conditions are necessary when the petroliferous formations are saturated with water:

a. There must be a porous stratum which may absorb large quantities of oil and so serve as a reservoir. This porous formation is commonly a sandstone of not too close cementation. Porous limestones also serve as reservoirs, especially those of dolomitic character, since the process of dolomitization causes a porosity to develop even in limestones which were originally compact. Where a dolomitic limestone is known to exist, and the depth and other necessary geologic conditions are satisfactory, the formation should be tested even if a sandstone at less depth yielded no oil.

b. The porous stratum should be capped by an impervious stratum which will thus prevent the upward migration of oil from the porous horizon. Thick shale beds and compact limestones serve for such cap rocks, the shales acting more efficiently in this capacity.

c. The formations originally in practically horizonal attitudes, must be so warped, tilted, or otherwise distorted as to form structures such as domes, anticlines, or terraces (fig. 79A and B). The variability of dip, or "slope" of the strata thus allows oil and gas to pass upward along the steeper dips and come to rest in those parts of the structures where the dips approach zero (horizontality).

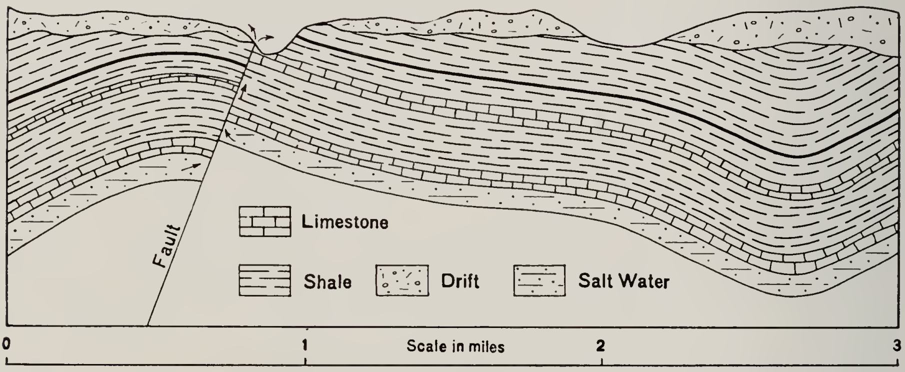

FIG. 80. Diagrammatic cross section showing the effect of geologic structure on oil accumulation. The fault plane has afforded a channel by which the oil escaped from the oil-bearing stratum.

Where the petroliferous formations are free from water, oil may accumulate in the basin-like depressions, or lower parts of the folds, as in figure 79C. In this case, the oil-accumulating formation must be underlain by an impervious stratum.

The formations serving as reservoirs and impervious capping must not be appreciably broken by deeply extending fissures known as faults, along which the individual beds are broken and displaced vertically (fig. 80).

If the oil sand underlies but a portion of the otherwise favorable structure, only that portion is available for successful drilling. Such discontinuous sands can be located only by drilling. It sometimes happens that one of these sand beds lies only upon the side of a dome or anticline, and thus a hole drilled through the top of the structure will give no yield, whereas one drilled through the side may reach the productive sand lens. The "Hoing sand" of this region, occurring as isolated patches at the base of the Niagaran limestone, is of this character (fig. 81).

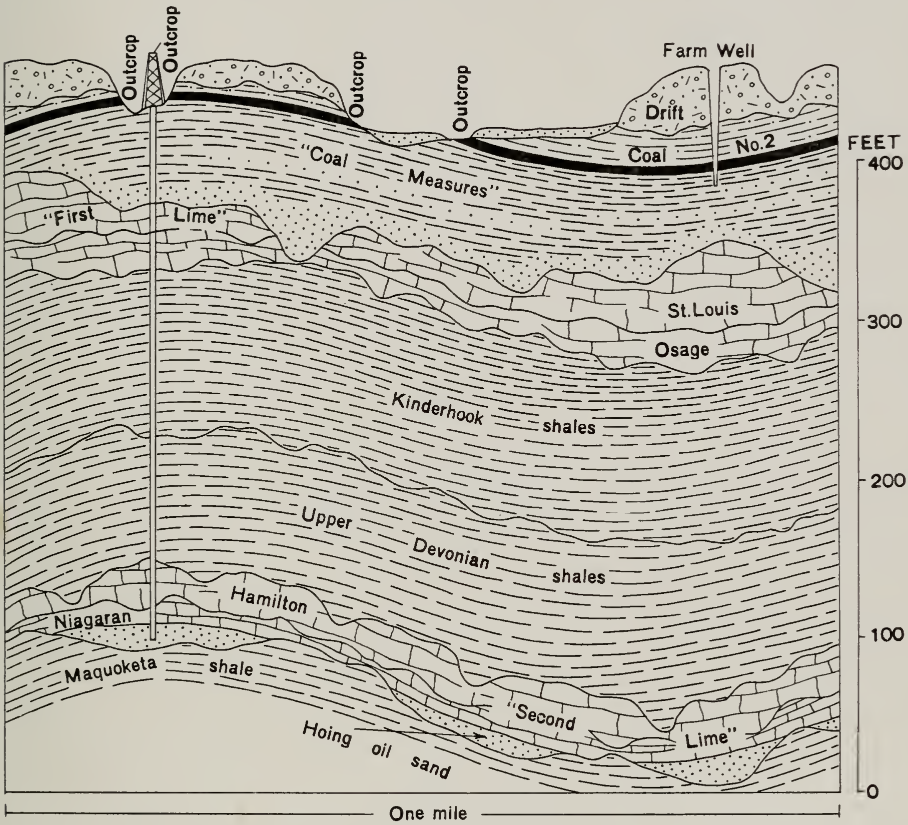

FIG. 81. Diagram showing the significance of unconformities in the Colmar region.

POSSIBLE OIL HORIZONS IN THIS AREA

In several instances, the porous portion of the Niagaran limestone has been found to contain a heavy oil. The Pike County gas-field wells produce from this horizon.

In the Colmar field, oil is produced from the Hoing sand, at the base of the Niagaran limestone. The Hoing sand is described briefly in an earlier portion of this paper (p. 318). Drilling to this horizon is a more uncertain operation than would be the case were it continuous over extensive areas, as it is not possible to determine its presence or absence at any point in advance of drilling as shown in figure 81.

The porous, white St. Peter sandstone below the Kimmswick-Plattin formation is not known as an oil-producing horizon in this district, although it shows oil in exceptional cases in Indiana and Ohio.

In eastern Illinois, the Kimmswick-Plattin of dolomitic character and equivalent to the productive Trenton formation of Ohio and Indiana, has given moderate results in drilling. In the western part of the State, the few wells that have been drilled to this formation have given no yield, but the Kimmswick-Plattin, which is the equivalent of the so-called "Trenton" of Clark County, has not been thoroughly tested up to the present time. However the production in the "Trenton" in Monroe County draws attention to the possibility of production in this horizon in other counties farther north.

DISCUSSION OF STRUCTURE

The structure map, Plate VII, shows two areas of marked doming, one in T. 1 N., R. 5 W., and the other in the northern part of T. 1 N., R. 7 W., and the southern part of T. 2 N., R. 7 W. Suggestions of a third dome appear midway between them but the data for this latter area are too scant to give assurances of any definite structure.

The dome in T. 1 N., R. 5 W., as plotted, shows its highest point in the northern half of section 24. The exact crest is unknown. Two tests were made in this township but neither yielded oil. Their positions, however, are far from the favorable portion of the dome as here mapped. One of them in SE. ¼ NE. ¼ section 15, practically on the boundary with section 14, is seen to be placed in a very low and flattened part of the dome. To the northwest of this position field data are lacking so that the true character of this section is unknown. It may be a terrace of small dimensions and only slightly above the nearby area of depression. The position of drilling was distinctly unfavorable, according to this interpretation of structure. Another test, also dry, was drilled in the NW. ¼ section 22, and its altogether unfavorable position is readily seen. According to the structure mapped in this section, the hole is in an area of depression. Southwest from the crest of the dome, in section 24, the slope of the structure is seen to decrease until beyond the NE. ¼ section 27 and NW. ¼ section 26, when the structure again rises to a slight elevation in the general vicinity of SE. ¼ section 27. This minor doming is probably too slight to be of any promise for oil drilling. Unfortunately field information is scant concerning this locality, the interpretation being based on the records of four water wells. If further tests are made in this township, the holes should be placed in the central-eastern part of section 23 and the northern half of section 24. The entire dome, while of favorable height, is, however, of unfavorably small areal extent.

The western dome, T. 1 N., R. 7 W., and T. 2 N., R. 7 W., covers a much larger area than the structure previously described. Its crest is apparently in the SW. ¼ sec. 34, T. 2 N., R. 7 W., and adjoining quarter-sections. To the north the structural slope drops gradually, though possible minor flexures on the north side of the dome can not be plotted because of insufficient data. Easterly from the crest, the slope is still more gradual. The south side of the dome, after a drop of forty or fifty feet, again rises into a smaller domal area. The latter is too small to warrant early testing. Other minor structures are suggested to the east and southwest. No oil tests have been made in this region.

Midway between the two areas described above, in N. ½ T. 1 N., R. 6 W., are indications of broad doming. Because of the slight topography, and the obscurity in the Pottsville formation which appears here at the surface, no well-defined area can be mapped. The highest points observed were in sections 3 and 11.

INDEX

A

PAGE

Adams County, alluvium in..... 310
  Carbondale formation in 311-312
  columnar section of rocks, exposed in 309-310
  drift in 311
  fossils in Pottsville formation in 314
  fossils in St. Louis formation in 315
  Keokuk formation in.........317–318
  key horizons used in determination of structure in....... 308
  loess in 310–311
  McLeansboro formations in...311–312
  Mississippian formations in...315–318
  No. 2 coal in.................313, 315
  oil horizons in................321–322
  Pennsylvanian formations in..311–315
  Pottsville formation in.......314–315
  recommendations for oil drilling in 322
  St. Louis formation in........315–316
  Salem formation in.......... 316
  stratigraphy of 309–318
  structure of 307–308
  topography of 309
  Warsaw formation in......... 317
Alluvial deposits in:
  Adams County 310
  Kings quadrangle............ 259
  La Harpe and Good Hope quadrangles 61
  Morris quadrangle...........161–163
Anticline, description of........ 269

B

Barrett farm in Kings quadrangle, occurrence of Galena-Platteville limestone on..... 229

PAGE

Base level, description of....... 273
Beacon School, Illinoian drift in well near 236
Bell shaft, description of........191, 193
Belvidere, deposits of Silurian sediments near............. 26
  occurrence of Maquoketa shale at 270
Belvidere Lobe in Kings quadrangle, trend of............ 239
Big Four Wilmington Coal Company, description of mine of 189
Big Mound, location of Belvidere Lobe near 240
Big Mound kame in Kings quadrangle, description of.......251–252
Bishop, Tom, pre-Illinoian Pleistocene deposits on farm of..234–235
Black Hawk Park, elevation of rock surface near........... 276
  explanation for "Narrows" at.292–293
  occurrence of *Receptaculites* in quarries in 230
Blandinsville, log of coal shaft near 74
  structural terrace near........ 64
Bloomington drift sheet in Morris quadrangle 148–149
"Blowing wells" in Kings quadrangle, explanation for...... 302
Braidwood Manufacturing Company, description of mine of 189
Burlington limestone in La Harpe and Good Hope quadrangles, description of 29–31
  use of as key horizon......... 64
  water possibilities of.......... 87–89
Burson Knitting Company, elevation of St. Peter sandstone in well of................. 270

PAGE
Bushnell, location of small done near 64
log of well at................ 19
occurrence of Edgewood limestone near 26
water supply of.............89, 90, 91
Byron, elevation of sandstone in well near 269
evidence of deformation in formations near 268
fossils in limestone near..230–231, 232
"freezing well" near......... 302
gravel pits near.............. 298
Late Wisconsin valley trains near 256
occurrence of Platteville limestone near 229
Potsdam sandstone in well at. 221
record of well at.............. 225
sand dunes near............. 259
water supply of............... 298

C

Calcite, composition of......... 223
Calhoun County, outcrops of "Lower Magnesian" limestone in 23
Cambrian history of:
Kings quadrangle 261-263
La Harpe and Good Hope quadrangles 65
Morris quadrangle 169
Cambrian system in:
Kings quadrangle 221–222
La Harpe and Good Hope quadrangles 22–23
Morris quadrangle 103–106
Camp Grant, gravel pits near.... 298
Late Wisconsin valley trains near 255–256
occurrence of *Receptaculites* in quarries near 230
sand dunes near............. 259
water supply for............. 301
Carbondale formation in:
Adams County 312–313
La Harpe and Good Hope quadrangles 48–51
Morris quadrangle 139–146

PAGE
Carrico quarry, ripple marked surface of Galena limestone in 265–266
Carroll County, Silurian system in 26
Cedar Valley limestone in La Harpe and Good Hope quadrangles 28
Cement rock in La Harpe and Good Hope quadrangles.... 80
Cenozoic history of:
La Harpe and Good Hope quadrangles 69–72
Morris quadrangle 173–184
Central, occurrence of Galena dolomite near 115, 116, 118
Champaign drift sheet in Morris quadrangle 148
Channahon, deposits of Silurian sediments near 26
sand and gravel deposits near. 155
Clay products from:
drift deposits in La Harpe and Good Hope quadrangles..... 72
Pennsylvanian formations in La Harpe and Good Hope quadrangles 72–75
Clay resources of:
La Harpe and Good Hope quadrangles 72–75
Morris quadrangle....148–149, 194–197
Clayton Brothers, description of mine of 189
Cleveland, E. W., cave encountered in drilling well of..... 294
Coal City, anticlinal structures near 166, 203
coal dumps near.............192, 193
lacustrine deposits near....... 154
No. 2 coal near............... 187
Pleistocene clay deposits near.196–197
sand dune area near..........157, 162
shale in mine dumps near..... 196
synclinal structures near......141, 203
Coal mining in Morris quadrangle 192–193
Coal No. 1 (Rock Island) in La Harpe and Good Hope quadrangles 40–48, 75–76

PAGE
Coal No. 2 in:
  Adams County 313, 315
  La Harpe and Good Hope quadrangles 49–50, 76–77
  Morris quadrangle 134, 137, 140, 141, 143, 144, 146, 185–191
Coal No. 4 in Morris quadrangle 192
Coal No. 5 in La Harpe and Good Hope quadrangles 77
Coal No. 7 in Morris quadrangle.144–146
Coal resources of:
  La Harpe and Good Hope quadrangles 75–77
  Morris quadrangle 185–193
Contour-plowing, value of...... 304
Copper, occurrence of in glacial drift in Kings quadrangle...214–215
Copper in La Harpe and Good Hope quadrangles 81
Corlet farm in Kings quadrangle, Illinoian drift in well on.... 236
Croixan sandstone in Kings quadrangle 221–222
Croixan sandstone, *see also Potsdam sandstone* ....
Cryder Lake in Morris quadrangle, description of.......180–183
Cryder Lake sub-stage, geologic history of Morris quadrangle during 180–183
Custer Park, deposits of Silurian sediments near 26
Cycle of erosion, description of..270–273

D

Davis Junction, buried valley near 276
  Illinoian drift in well near.... 236
  kame near 255
  location of Belvidere Lobe near 240
  water supply from well at.....299–301
Decorah shale in La Harpe and Good Hope quadrangles.... 25
Decorra, water supply of....... 89
Deformation of formations in Kings quadrangle 268–270
Devonian system in La Harpe and Good Hope quadrangles 28
Diastrophism, effect of......... 215

PAGE
Divine, gravel pit near..........158, 162
Dixon, outcrop of St. Peter sandstone near 223
Dolomite, composition of........ 223
  mode of formation of........ 268
Drift gas in La Harpe and Good Hope quadrangles 87
Drift in:
  Adams County 311
  Kings quadrangle.....214–215, 232–258
  La Harpe–Good Hope quadrangles 51–61
  Morris quadrangle 147–161

E

Early Wisconsin and Illinoian drifts in Kings quadrangle, criteria for differentiation of.241–243
Early Wisconsin drift in Kings quadrangle, composition of.. 244
  description of 239–255
  fossils in.....................240–241
Early Wisconsin glacial history of Kings quadrangle........290–292
Economic geology, *see Mineral resources*
Edgewood limestone in La Harpe and Good Hope quadrangles 26
Elgin, occurrence of Silurian formations near 27
Eskers in Kings quadrangle, formation of 251
Essex, deposits of Silurian sediments near 26
Evans, Ted, pre-Illinoian Pleistocene deposits on farm of.... 235

F

Fairdale, occurrence of Maquoketa shale at.............. 270
Floodplains, description of...... 259
Flowing wells in Kings quadrangle 301–302
Fluvial deposits in Morris quadrangle 154–161
Forreston, outcrop of Prairie du Chien limestone near........ 223

PAGE

Fossiliferous loess in quarry in Kings quadrangle, Galena dolomite thrust upon....... 240
Fossils in:
  Burlington limestone in La Harpe quadrangle........ 30, 31
  Carbondale formation in La Harpe and Good Hope quadrangles............. 50–51
  Early Wisconsin drift in Kings quadrangle..............240–241
  Galena dolomite in Morris quadrangle......114, 115, 116, 118
    in Kings quadrangle....228, 230, 232
  Keokuk formation in Adams County.................. 317
    in La Harpe quadrangle..... 32
  Maquoketa formation in Morris quadrangle.......122, 123, 124
  Pennsylvanian system in Morris quadrangle........... 133
  Platteville limestone in Kings quadrangle..............230–232
  Pleistocene deposits in Morris quadrangle.............. 159
  Potsdam sandstone in Kings quadrangle..............262–263
  Pottsville formation in Adams County.................. 314
    in La Harpe and Good Hope quadrangles......42, 44, 45, 46, 47
  St. Louis formation in Adams County.................. 315
  Warsaw formation in Adams County.................. 317
Fossils, use of in correlation studies................213–214, 226
"Freezing wells" in Kings quadrangle, explanation for...... 302

G

Galena dolomite upon fossiliferous loess in quarry near Camp Grant, tilted ledges of 240
Galena dolomite in Kings quadrangle, description of.......226–232
  fossils in.................228, 230, 232
  history of.................. 265
  nodules in.................. 268
  thickness of................ 229
  water possibilities of..........299–301
Galena dolomite in Morris quadrangle, description of...107, 113–120
  fossils in............114, 115, 116, 118
  history of.................. 170
  oil and gas possibilities of..... 203
  quarries in.................. 197
  structure of.................. 165
  use as fertilizer of............197–198
  water possibilities of..........200, 201
Galena dolomite near White Rock, outcrop of........... 285
Galena-Platteville limestone, lead and zinc deposits in......... 25
Galena-Platteville limestone in La Harpe and Good Hope quadrangles, description of.. 24–25
  history of.................. 65
  oil possibilities of............ 84
Gas and oil in La Harpe and Good Hope quadrangles.... 81–87
Gas and oil possibilities of Morris quadrangle.............203–204
Gas in glacial drift in La Harpe and Good Hope quadrangles 87
Geodes in Warsaw formation in Adams County............ 317
Geologic history of:
  Kings quadrangle............261–295
  La Harpe and Good Hope quadrangles................ 64–72
  Morris quadrangle...........169–184
Girardeau limestone in La Harpe and Good Hope quadrangles 26
Glaciation, cause of............ 281
Gneiss, in glacial drift in Kings quadrangle, occurrence of... 214
Gochenour farm, log of well on.. 21
Good Hope, structural dome near 63
  water supply of.............. 89
Good Hope quadrangle, alluvial deposits in............... 61
  Burlington limestone in....... 29–31
  Cambrian system in........... 22–23
  Carbondale formation in...... 48–51
  Cedar Valley limestone in..... 28
  cement rock in............... 80
  clay and shale deposits in...... 72–75
  clay products from deposits in. 72–75

PAGE
  Coal No. 1 (Rock Island) in 40–48, 75–76
  Coal No. 2 in 49–50, 76–77
  Coal No. 5 in 77
  coal resources of 75–77
  copper in 81
  culture of 17
  Decorah shale in 25
  detailed well records in 18
  Devonian system in 28
  drainage of 16
  drift gas in 87
  Edgewood limestone in 26
  fossils in Carbondale formation in 50–51
  Galena-Platteville limestone in. 24–25
  gas in glacial drift in 87
  geologic history of 64–72
  Girardeau limestone in 26
  Hoing sand in 26
  Illinoian drift in 56–58
  iron deposits in 80–81
  Kankakee limestone in 26
  Kansan (?) drift in 52–55
  Keokuk limestone in 31–33
  Kinderhook shale in 28–29
  lime in 78
  limestone in 78
  location of 13
  loess in 60–61
  "Lower Magnesian" limestone in 23
  Maquoketa shale in 25–26
  mineral resources of 72–93
  Mississippian system in 28–38
  Niagaran dolomite in 27
  oil and gas in 81–87
  oil posibilities of Galena-Platteville limestone in 82–84
  Orchard Creek shale in 26
  Ordovician system in 23–26
  Pennsylvanian system in 38–51
  Pleistocene series in 52-61
  Pottsville formation in 39–48
  "Potsdam" sandstone in 22–23
  pre-glacial topography in 70
  Quaternary system in 51–61
  Recent series in 61

PAGE
  recommendations for prospecting for shales in 74
  recommendations for testing for oil and gas in 86–87
  Rock Island coal in 40–48
  St. Louis limestone in 34, 35–38
  St. Peter sandstone in 23–24
  Salem formation in 34–35
  sand and gravel in 78–79
  sandstone in 77
  Sangamon soil zone in 58–59
  Silurian system in 26–27
  soil resources of 92–93
  sphalerite in 80–81
  Sporangites huronense in 28
  Stigmaria sandstone in 40
  stratigraphy of 18-61
  structure of 61–64
  Sweetland Creek shale in 28
  topography of 13–16
  transportation in 17
  Wapsipinicon limestone in 28
  Warsaw formation in 33–34
  water resources of 87–92
  Yarmouth (?) soil horizon in 52, 55–56
  zinc and lead in 80–81
Goose Lake, Maquoketa formation near 124
  No. 2 coal near 186
  Pennsylvanian shale deposit near 194, 195
  Pottsville formations near 136
Granite in glacial drift in Kings quadrangle, occurrence of 214
Gravel pits in Kings quadrangle 297–298
Greenbush, water supply of 89
Ground water in Kings quadrangle, solvent action of 212, 213
Gullying, prevention of 303–304

H

Haeger Brick and Tile Company, description of clay mine of 194–195
Hancock County, log of oil well in 21
  log of old coal shaft near La Harpe in 74
Harrisville, cave near 295

PAGE
location of Belvidere Lobe near 240
Heather shaft, description of....191, 193
Henderson County, log of well in 19
oil and gas showings in........ 82
Historical geology of:
Kings quadrangle 261–295
La Harpe and Good Hope quadrangles 64–72
Morris quadrangle 169–184
Hoge, Abe, well on farm of.....103, 105
Hoing sand in Adams County, occurrence of 321
in La Harpe and Good Hope quadrangles, description of..26, 82-83
Holcomb, Early Wisconsin drift near 242
location of buried valley near. 276
occurrence of *Receptaculites* in outcrop of Galena near..... 230
Holcomb kame tract in Kings quadrangle, description of...252, 290

I

Illinoian and Early Wisconsin drifts in Kings quadrangle, criteria for differentiation of.241–243
Illinoian drift in:
Kings quadrangle 235-239
La Harpe and Good Hope quadrangles 56–58
Illinoian glacial history of:
Kings quadrangle 278–283
La Harpe and Good Hope quadrangles 71–72
Morris quadrangle 173
Illinois, oldest rocks exposed in.. 23
Iron deposits in La Harpe and Good Hope quadrangles.... 80–81

J

Jointing in limestone formations in Kings quadrangle 268
Jugtown, Pennsylvanian shale deposit near 194, 195, 196, 197

K

Kames in Kings quadrangle, formation of 251

PAGE
Kankakee limestone in La Harpe and Good Hope quadrangles 26
Kansan (?) drift in La Harpe and Good Hope quadrangles 52–55
Kennedy Bluff, occurrence of *Receptaculites* in outcrop of Galena near 230
Keokuk formation in:
Adams County 317–318
La Harpe and Good Hope quadrangles 31–33
Killbuck, gravel deposits near.. 252
Killbuck kame tract in Kings quadrangle, description of..252–253
Kimmswick-Plattin formation in Adams County, oil possibilities of 322
Kinderhook shale in La Harpe and Good Hope quadrangles 28–29
Kings kame tract in King's quadrangle, description of....254–255, 290
Kings quadrangle, aggradational changes in 211–217
alluvium in 259
annual rainfall in............ 211
Cambrian history of..........261–263
composition of drift in........214–215
Croixan sandstone in.........221–222
deformation of formations in.268–270
degradational changes in......211–217
depressions in drift in........ 285
description of Government land survey in 209–210
drainage changes in rivers in.. ....283, 290, 293, 294
drainage of 210, 211–212
Early Wisconsin drift in......239–255
Early Wisconsin glacial history of 290–292
economic geology of..........297–304
evidence of pre-Illinoian interglacial epoch in.............278–283
fossils in Early Wisconsin drift in 240–241
Galena limestone in.....228–230, 232
Platteville limestone in......230–232
Potsdam sandstone in.......262–263
Galena formation in..........226–232
Galena history of............ 265
geologic history of...........261–295

PAGE
geological changes in..........211–217
gravel pits in..................297–298
Illinoian drift in..............235–239
Illinoian glacial history of....278–283
interval between Early Wisconsin and Late Wisconsin epochs, evidence of......... 292
Killbuck valley train in....... 255
Late Wisconsin drift in.......255–258
Late Wisconsin glacial history of 292–293
limestone resources of........ 297
location of 209
loess in 238–239
"Lower Magnesian" limestone in 222–223
measurement of flow of streams in 212
mineral resources of..........297–304
Ordovician history of.........263–266
Platteville formation in.......226–232
Platteville history of..........265–266
Pleistocene deposits in........232–258
Pleistocene history of.........277–293
post-glacial history of.........293–295
post - Illinoian, pre - Wisconsin history of 283–288
post - Ordovician, pre - Pleistocene history of............265–266
Potsdam history of...........261–263
Potsdam sandstone in.........221–222
Prairie du Chien history of....263–264
Prairie du Chien limestone in.222–223
pre-Illinoian topography in....273–277
pre-Illinoian gravel in.........232–235
Recent deposits in............258–259
St. Peter history of...........264–265
St. Peter sandstone in.........223–226
soil resources of..............302–304
stratigraphy of 219–259
topography of 210
trend of Belvidere Lobe in....239–240
"Trenton" formation in.......226–232
water resources of...........298–302
Wisconsin drift in............239–258
Wisconsin glacial history of...288–293
Kishwaukee River, drainage changes in 283, 294
Kishwaukee School, Belvidere Lobe near 240

L

PAGE
Lacustrine deposits in Morris quadrangle.148–149, 154–161, 178–183
La Harpe quadrangle, alluvial deposits in 61
Burlington limestone in....... 29–31
Cambrian system in........... 22–23
Carbondale formation in...... 48–51
Cedar Valley limestone in..... 28
cement rock in............... 80
clay and shale deposits in..... 72–75
clay products from deposits in. 72–75
Coal No. 1 (Rock Island) in.. ....40–48, 75–76
Coal No. 2 in.............49–50, 76–77
Coal No. 5 in................ 77
coal resources of............ 75–77
copper in 81
culture of 17
Decorah shale in............. 25
detailed well records in........ 18
Devonian system in........... 28
drainage of 16
drift gas in.................. 87
Edgewood limestone in....... 26
fossils in:
Burlington limestone in..... 30, 31
Carbondale formation in.... 50–51
Keokuk limestone in........ 32
Galena-Platteville limestone in 24–25
gas in glacial drift in.......... 87
geologic history of........... 64–72
Girardeau limestone in........ 26
Hoing sand in................ 26
Illinoian drift in............. 56–58
iron deposits in............... 80–81
Kankakee limestone in........ 26
Kansan (?) drift in.......... 52–55
Keokuk limestone in.......... 31–33
Kinderhook shale in.......... 28–29
lime in 78
limestone in 78
location of 13
loess in 60–61
log of old coal shaft near..... 74
"Lower Magnesian" limestone in 23
Maquoketa shale in.......... 25–26

PAGE
mineral resources of.......... 72–93
Mississippian system in........ 28–38
Niagaran dolomite in......... 27
oil and gas in................. 81–87
oil possibilities of............ 82–84
Orchard Creek shale in....... 26
Ordovician system in.......... 23–26
Pennsylvanian system in...... 38–51
Pleistocene series in.......... 52–61
Pottsville formation in........ 39–48
"Potsdam" sandstone in....... 22–23
pre-glacial topography in...... 70
Quaternary system in......... 51–61
Recent series in.............. 61
recommendations for prospecting for shale in............. 74
recommendations for testing for oil and gas in........... 86–87
Rock Island coal in........... 40–48
St. Louis limestone in........34, 35–38
St. Peter sandstone in........ 23–24
Salem formation in........... 34–35
sand and gravel in............ 78–79
sandstone in 77
Sangamon soil zone in........ 58–59
Silurian system in........... 26–27
soil resources of............. 92–93
sphalerite in 80–81
Sporangites huronense in...... 28
Stigmaria sandstone in........ 40
stratigraphy of 18–61
structure of 61–64
Sweetland Creek shale in..... 28
topography of 13–16
transportation in 17
Wapsipinicon limestone in..... 28
Warsaw formation in......... 33–34
water resources of........... 87–92
Yarmouth(?) soil horizon in.52, 55–56
zinc and lead in............. 80–81
Lake deposits in Morris quadrangle 148–149, 154–161, 178–183
Lake Morris history of Morris quadrangle 178–180
La Salle anticline, effect of on formations in Kings quadrangle 269
trend of 269
La Salle County, outcrops of "Lower Magnesian" (Prairie du Chien) limestone in..... 223
Late Wisconsin drift in Kings quadrangle 255–258
Late Wisconsin glacial history of Kings quadrangle 292–293
Lead and zinc deposits in Galena-Platteville limestones 25
"Lead sponge," *see Receptaculites*
Leaf River, drainage changes in.. ....283, 290, 293
Lee County, outcrops of "Lower Magnesian" limestone in.... 23
Leighton, M. M., work of....... ....234, 238, 239, 279
Lime in La Harpe and Good Hope quadrangles 78
Limerick School, water supply of 298
Limestone resources of:
Kings quadrangle 297
La Harpe and Good Hope quadrangles 78
Morris quadrangle 197–198
Lindenwood, location of buried valley near 276
Lisbon, location of quarry near.. 197
Little Mound, early Wisconsin gravel deposits near........ 246
flowing well near............ 302
Loess in:
Adams County 310–311
Kings quadrangle 238–239
La Harpe and Good Hope quadrangles 60–61
Logs of strata penetrated in wells at, in, or near:
Blandinsville 74
Bushnell 19
Byron 225
Hancock County 21
Henderson County 19
La Harpe 74
McDonough County 19, 44
Rockford 222
Stronghurst 19
Long Point School, sand and gravel deposits showing delta bedding near 176

PAGE

Love Manufacturing Company, elevation of St. Peter sandstone in well of............ 269
"Lower Magnesian" limestone in:
  Kings quadrangle 222–223, 263–264
  La Harpe and Good Hope quadrangles 23, 65
  Morris quadrangle 106–107, 169–171, 200

M

McLeansboro formations in Adams County 311–312
McDonough County, log of coal shaft near Blandinsville in.. 74
  logs of wells in............... 19, 44
Magnesite, composition of....... 223
Mantle rock, description of...... 217
Maquoketa formation in:
  La Harpe and Good Hope quadrangles, description of..25–26, 83–84
  Morris quadrangle, description of 120–128, 165, 194, 198
Marl in Morris quadrangle, occurrence of 158, 198
Marseilles drift sheet in Morris quadrangle 148, 149–153
Marseilles history of Morris quadrangle 174–177
Media, gas and oil showings near 82
Mesozoic history of:
  La Harpe and Good Hope quadrangles 69
  Morris quadrangle 173
Mineral resources of:
  Kings quadrangle 297–304
  La Harpe and Good Hope quadrangles 72–93
  Morris quadrangle 185–204
Minooka drift sheet in Morris quadrangle 150–154
Minooka history of Morris quadrangle 177–183
Mississippian system in:
  Adams County 315–318
  La Harpe and Good Hope quadrangles 28–38
Mitchell shaft, description of....191, 193
Morris, Carbondale outcrops near 139

PAGE

  lacustrine deposits near....... 149
  location of lake during Bloomington stage near........... 174
  marl deposits near............158, 183
  peat deposits near............. 183
  Pleistocene clay near......... 196
  sand deposits near............ 183
  sand and gravel pit near...... 158
  strip mine near............... 193
  water supply of............... 199
Morris-Kankakee anticline, folding of 165, 166
Morris quadrangle, absence of No. 6 coal in...............143–144
  analyses of No. 2 coal in......187–188
  Bloomington drift sheet in....148–149
  Cambrian history of.......... 169
  Cambrian system in..........103–106
  Carbondale formation in......139–146
  Cenozoic history of..........173–184
  Champaign drift sheet in...... 148
  chemical composition of No. 2 coal in 187–188
  clay deposits in...............148–149
  clay resources of............194–197
  Coal No. 2 in..............134, 136, 137, 140, 141, 143, 144, 146, 185–191
  Coal No. 4 in................. 192
  Coal No. 7 in.................144–146
  coal resources of.............185–193
  Cryder Lake, history of.......180–183
  culture in 102–103
  drainage of 101–102
  early coal mining in..........192–193
  economic possibilities of shales in 194–196, 197
  fertilizer in, occurrence of.....197–198
  fluvial deposits in.............154–161
  fossils from:
    Pleistocene deposits in...... 159
    Galena dolomite in..114, 115, 116, 118
    Maquoketa formation in.122, 123, 124
    Pennsylvanian system in.... 133
  Galena dolomite in........107, 113–120
  historical geology of..........169–184
  Illinoian history of.......... 173
  lake deposits in............... ....148–149, 154–161, 178–183
  Lake Morris, history of.......178–180

PAGE
later history of Illinois Valley in 183–184
limestone resources of........197–198
location of 99
"Lower Magnesian" series in..106–107
Maquoketa formation in......120–128
marl deposits in............. 198
Marseilles drift sheet in..148, 149–153
Marseilles geologic history of.174–177
Mesozoic geologic history of.. 173
mineral resources of..........185–204
Minooka drift sheet in........150–154
Minooka geologic history of...177–183
New Richmond sandstone in..106–107
oil and gas possibilities of.....203–204
Oneota formation in.......... 106
Ordovician geologic history of.169–171
Ordovician system in.........106–128
outcrops of Pennsylvanian strata in 130
Pennsylvanian history of......171–173
Pennsylvanian system in......128–146
Platteville limestone in....107, 111–113
Pleistocene geologic history of.173–184
Pleistocene system in.........147–161
Pottsville formation in........133–138
Prairie du Chien series in.....106–107
pre-Wisconsin drift in........ 147
production of No. 2 coal in.... 187
quarries in Galena dolomite in. 197
Recent deposits in............161–163
Richmond formation in.......120–128
St. Peter sandstone in.........107–111
sand and gravel deposits in....198–199
sandstone resources of........197–198
Shakopee dolomite in.........106–107
shale deposits in..............194–197
Shelbyville drift sheets in..... 148
soil resources of..............201–203
stratigraphy of 103–161
structural contours on bed rock surface of 151
structural geology of.........165–167
topography of 100–102
transportation in 102
water resources of...........199–201
Waupecan sandstone in.......143–145
Wisconsin drift in............148–161
Wisconsin history of.........173–183

PAGE
Mazon, occurrence of Maquoketa formation near 124
Mazon River, fossiliferous shales of 146
warping in Pennsylvanian strata along 167

N

New Milford, gravel deposits near 252
Illinoian drift in well near..... 236
Late Wisconsin valley trains near 256
pre-Illinoian Pleistocene deposits near 235
New Richmond sandstone in Morris quadrangle 106–107
Niagaran dolomite in La Harpe and Good Hope quadrangles 27, 82
Niagaran formation in Adams County, oil possibilities of... 321

O

Ogle County, Prairie du Chien ("Lower Magnesian") limestone in 23, 223
Oil and gas in La Harpe and Good Hope quadrangles 81–87
Oil and gas possibilities of Morris quadrangle 203–204
Oil horizons in Adams County...321–322
"Oil rock," description of....... 25
Oneota formation in Morris quadrangle 106
Orchard Creek shale in La Harpe and Good Hope quadrangles 26
Ordovician history of:
  Kings quadrangle 263–266
  La Harpe and Good Hope quadrangles 65–66
  Morris quadrangle 169–171
Ordovician system in:
  Kings quadrangle 222–232
  La Harpe and Good Hope quadrangles 23–26
  Morris quadrangle 106–128
Oregon, outcrop of Prairie du Chien limestone near....... 223

PAGE

outcrop of St. Peter sandstone near ... 223
Oswego, deposits of Silurian sediments near ... 26
Oxidation, effect of ... 212

P

Paines Point, outcrop of St. Peter standstone near ... 223
water supply of ... 298
Paleozoic history of Illinois ... 64–69
Peneplain, description of ... 273
Peneplain in Kings quadrangle, criteria for determination of ... 275–276
Pennsylvanian history of Morris quadrangle ... 171–173
Pennsylvanian outliers in Morris quadrangle, occurrence of ... 128, 138
Pennsylvanian sandstone in Morris quadrangle, water possibilities of ... 199
Pennsylvanian shale in Morris quadrangle, economic possibilities of ... 194–196, 197
Pennsylvanian strata in Morris quadrangle, outcrops of ... 130
structure of ... 165–166
Pennsylvanian system in:
Adams County ... 311–315
La Harpe and Good Hope quadrangles ... 38–51
Morris quadrangle, description of ... 128–146, 203–204
Pike County, Kankakee limestone in ... 27
Pine Bluff, faults near ... 167
Platteville history of Kings quadrangle ... 265–266
Platteville limestone in Kings quadrangle, description of ... 226–232, 299–301
Platteville limestone in Morris quadrangle, description of ... 107, 111–113
Pleistocene clay in Morris quadrangle, economic possibilities of ... 196–197
Pleistocene deposits in:
Adams County ... 311

PAGE

Kings quadrangle ... 214–215, 232–258, 298
La Harpe-Good Hope quadrangles ... 51–61
Morris quadrangle ... 147–161
Pleistocene history of:
Kings quadrangle ... 277–293
La Harpe and Good Hope quadrangles ... 71–72
Morris quadrangle ... 173–184
Porphyry in glacial drift in Kings quadrangle, occurrence of ... 214
Post-glacial history of Kings quadrangle ... 293–295
Post-Illinoian, pre-Wisconsin history of Kings quadrangle ... 283–288
Post-Ordovician, pre-Pleistocene history of Kings quadrangle ... 265–266
Postdam sandstone in Kings quadrangle, description of ... 221–222
fossils in ... 262–263
water possibilities of ... 298
Potsdam sandstone in La Harpe and Good Hope quadrangles 22–23
Potsdam sandstone in Morris quadrangle, water possibilities of ... 201
Pottsville formation in La Harpe and Good Hope quadrangles, recommendations for prospecting for shales in ... 74
Pottsville formation in Adams County, description of ... 314–315
Pottsville formation in La Harpe and Good Hope quadrangles, description of ... 39–48
distribution of ... 39–40
fossils in ... 42, 44, 45–46, 47
oil possibilities of ... 82
thickness of ... 39–40
water possibilities of ... 87–88
Pottsville formation in Morris quadrangle, correlation of ... 134–138
description of ... 133–138
thickness of ... 135
Prairie du Chien, *see "Lower Magnesian"*
Pre-glacial topography in La Harpe and Good Hope quadrangles ... 70

PAGE

Pre-Illinoian gravel in Kings quadrangle 232–235
Pre-Illinoian interglacial epoch in Kings quadrangle, evidence of 277
Pre-Illinoian topography in Kings quadrangle 273–277
Pre-Wisconsin drift in Morris quadrangle 147

Q

Quaternary, *see Pleistocene*

R

Rainfall in Kings quadrangle.... 211
Receptaculites in Galena limestone in Kings quadrangle, occurrence of 228, 229, 230
Recent deposits in:
  Kings quadrangle 258–259
  La Harpe and Good Hope quadrangles 61
  Morris quadrangle 161–163
Recommendations for oil and gas drilling in La Harpe and Good Hope quadrangles..... 86–87
Recommendations for oil drilling in Adams County 322
Richmond formation in Morris quadrangle 120–128
Ripple marked surface of Galena limestone in Carrico quarry.265–266
Rochelle, occurrence of Maquoketa shale at............... 270
Rockford, elevation of sandstone in well near................ 269
  fossils in limestone near....... 232
  gravel pits near............. 298
  Late Wisconsin valley trains near 255–256
  loess deposit near............ 258
  partial log of well in.......... 222
  Potsdam sandstone in well at.. 221
  water supply of............. 298
Rockford Malleable Iron Works, elevation of rock surface near 276
  Illinoian drift in well of...... 236

PAGE

Rock Island coal in La Harpe and Good Hope quadrangles..... 40–48
Rock River, drainage changes in.283, 293
Rocky Hollow, outcrop of limestone near 224
  outcrop of St. Peter sandstone near 224
Roseville, anticline near......... 64
  recommendations for testing for oil and gas near......... 87
  water supply of............... 89, 91

S

St. Charles, occurrence of Silurian formations near........ 27
St. Louis formation in Adams County, description of......315–316
  La Harpe and Good Hope quadrangles 34, 35–38
St. Peter history of Kings quadrangle 264–265
St. Peter sandstone in Kings quadrangle, description of...223–226
  structure of 269–270
  water possibilities of......... 298
St. Peter sandstone in La Harpe and Good Hope quadrangles, description of 23–24
  origin of 24
  thickness of 24
St. Peter sandstone in Morris quadrangle, description of...107–111
  structure of 165
  thickness of 108
  water possibilities of..........199–200
Salem formation in:
  Adams County 316
  La Harpe and Good Hope quadrangles 34–35
Sand and gravel deposits in:
  La Harpe and Good Hope quadrangles 78–79
  Morris quadrangle 198–199
Sand and gravel pit near Morris. 158
Sand dunes in Morris quadrangle 157, 162–163
Sandstone in La Harpe and Good Hope quadrangles 77

PAGE
Sandstone resources of Morris quadrangle 197–198
Sangamon soil zone in La Harpe and Good Hope quadrangles 58–59
Sciota, water supply of.......... 89
Sediments in Kings quadrangle, cementation and consolidation of 267
Seneca, Carbondale formation near 142
  Coal No. 2 near.............. 187
  lacustrine deposits near....... 149
  location of lake during Bloomington stage near........... 174
Shakopee dolomite in Morris quadrangle 106–107
Shale deposits of Morris quadrangle 194–197
Shelbyville drift sheet in Morris quadrangle 148
Silurian dolomite in La Harpe and Good Hope quadrangles, description of 26–27
  oil possibilities of............ 82
Sinks, description of........... 294
Sinks in Kings quadrangle, occurrence of 295
Soil resources of:
  Kings quadrangle 302–304
  La Harpe and Good Hope quadrangles 92–93
  Morris quadrangle 201–203
Sphalerite in La Harpe and Good Hope quadrangles 80–81
Sporangites huronense in La Harpe and Good Hope quadrangles, occurrence of...... 28
Stigmaria sandstone in La Harpe and Good Hope quadrangles. 40
Stillman Creek, Late Wisconsin lake near 257–258
Stillman Valley, Belvidere Lobe near 239
  early Wisconsin gravel deposits near 246
  fossils in limestone near...... 231
  gravel pits near.............. 298
Stillman Valley eskerine tract, description of 246–250
  formation of 290

PAGE
Stratigraphy of:
  Kings quadrangle 219–259
  La Harpe and Good Hope quadrangles 18–61
  Morris quadrangle 103–163
Stronghurst, log of well at...... 19
  recommendations for testing for oil and gas near......... 87
  structural dome near.......... 63
  water supply of.............. 89–90
Structure, importance of for oil accumulation 320–321
Structure of:
  La Harpe and Good Hope quadrangles 61–64
  Morris quadrangle 165–167
Sulphur Springs, Carbondale formation near 143, 146
  coal near 192
  water supply of............... 199
"Sunflower" coral, *see Receptaculites*
Swan Creek, water supply of.... 89
Sweetland Creek shale in La Harpe and Good Hope quadrangles 28
Syncline, description of......... 269

T

Till, *see Drift*
Topography of La Harpe and Good Hope quadrangles.... 13–16
"Trenton" formation in:
  Adams County, oil possibilities of 322
  Kings quadrangle 226–232, 265, 268, 299–301
  La Harpe and Good Hope quadrangles 24–25, 65, 84
  Morris quadrangle 107, 113–120, 170, 197–198, 200, 201, 203

U

Unconformity, description of.... 215
Unconformity in Adams County between Pottsville sandstone and St. Louis limestone..... 309

V

PAGE

Valley trains, formation of...... 257

Vergennes sandstone in La Harpe and Good Hope quadrangles, absence of 51

Vermilionville sandstone, correlation of Waupecan sandstone in Morris quadrangle with 145

Verona, Carbondale formation near 142

W

Wapsipinicon limestone in La Harpe and Good Hope quadrangles 28

Warren County, log of oil well in 20

Warsaw formation in:
- Adams County, description of. 317
- La Harpe and Good Hope quadrangles, description of...... 33–34

Water analyses from wells in La Harpe and Good Hope quadrangles 90–91

Water resources of:
- Kings quadrangle 298–302
- La Harpe and Good Hope quadrangles 87–92
- Morris quadrangle 199–201

Water table, description of...... 212

Waupecan sandstone in Morris quadrangle 143-145

PAGE

Weathering, results of.......... 217

White Rock, flowing well near.. 301
- Galena limestone near......... 285
- pre-Illinoian Pleistocene deposits near 235

Wilmington sand and gravel deposits near 155

Wilmington Star Mining Company, description of mines of 189

Wind, mechanical changes resulting from.................. 217

Wisconsin drift in:
- Kings quadrangle 239–258
- Morris quadrangle 148–161

Wisconsin glacial history of:
- Kings quadrangle 288–293
- Morris quadrangle 173–183

Y

Yarmouth(?) soil horizon in La Harpe and Good Hope quadrangles 52, 55–56

Youngstown, structural terrace near 64
- syncline near 64
- water supply of............. 89

Z

Zinc and lead in La Harpe and Good Hope quadrangles..... 80–81